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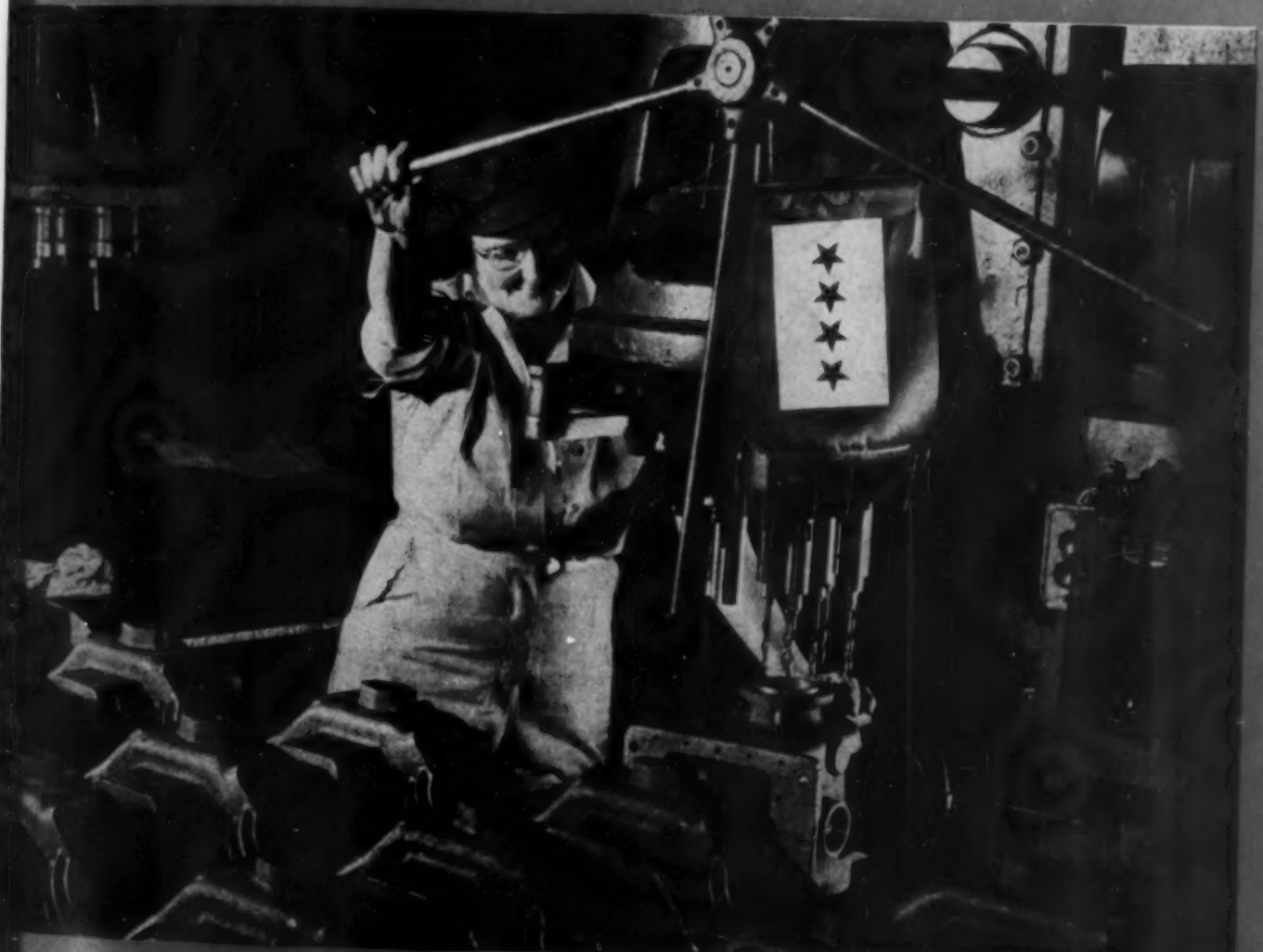
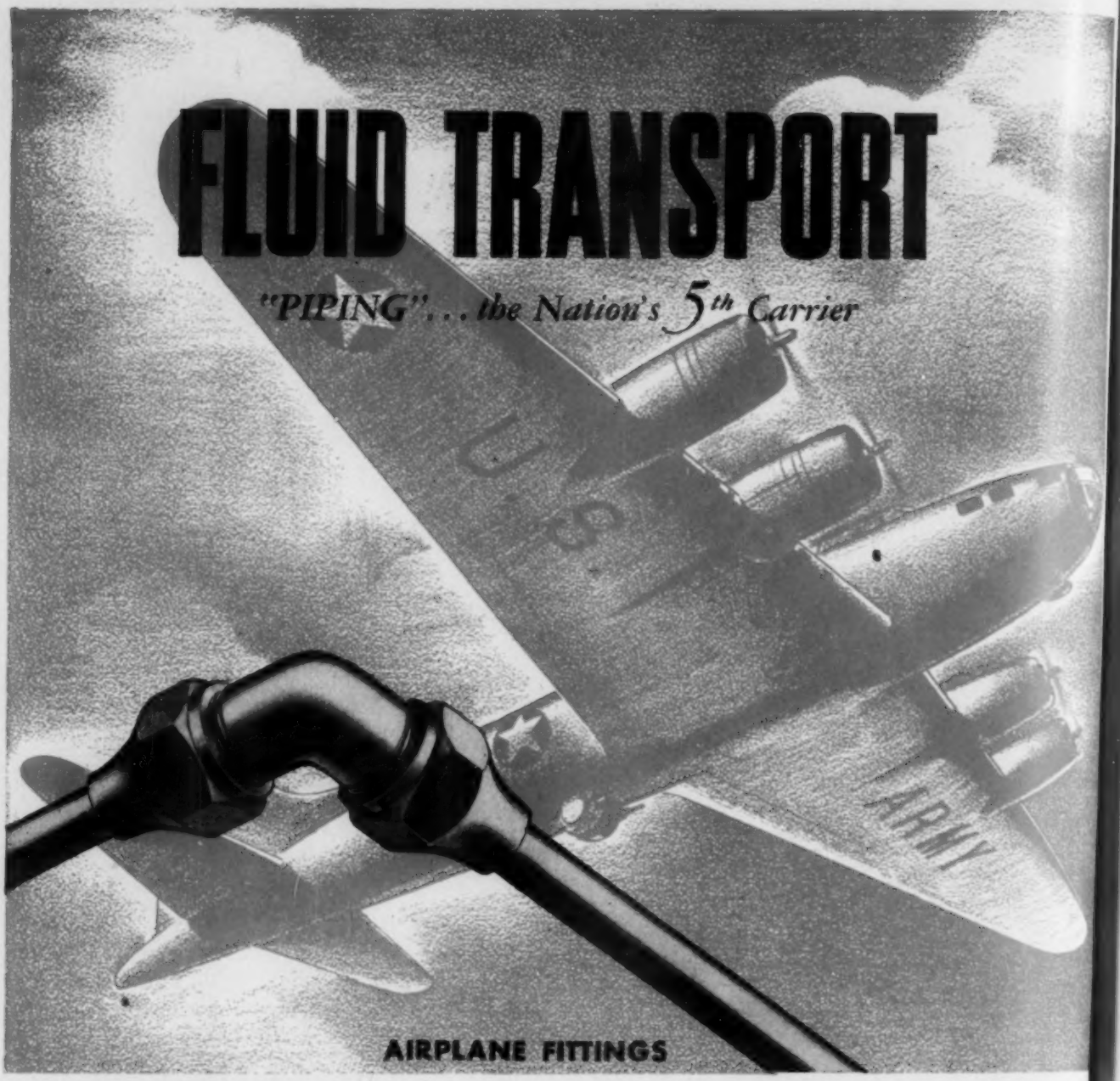
485: Journal Section of the American Society of Heating and Ventilating Engineers



Women in the air conditioning industry—Mrs. Jane Hopkins works at a multiple drill press

CONTENTS . . PAGE 69



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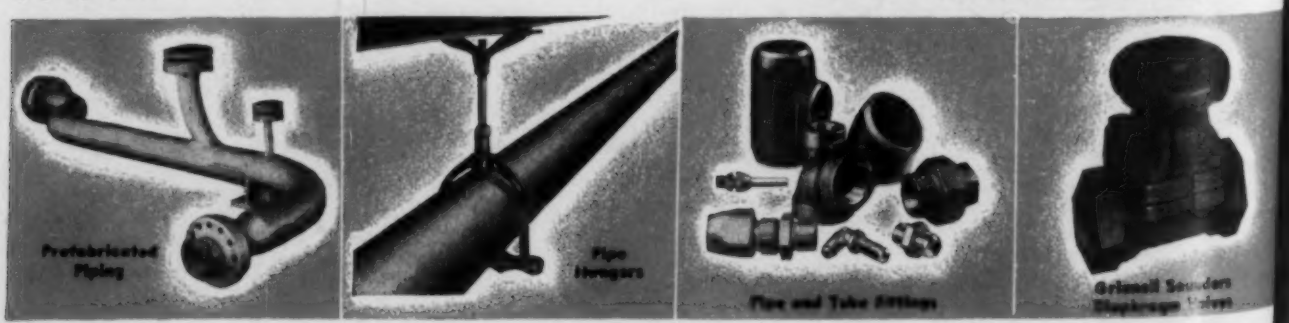

The Editor's Pages

ARMY-NAVY PRODUCTION AWARD GRANTED TO TOTAL OF 1910 PLANTS AND PROJECTS

A total of 1910 plants and projects have been granted the Army-Navy "E" for excellence in production of war materials, it was announced August 10 by Under Secretary of War Robert P. Patterson and Under Secretary of the Navy James Forrestal on the first anniversary of the presentation of the Army-Navy production awards. This is the first time since the joint award was inaugurated a year ago that the total number of awards has been made public.

No official compilation has been made of the total number of plants in this country, both prime and subcontractors, producing war materials for the United States and other Allied Nations. On the basis of several statistical reports, however, it is estimated that less than 2½ per cent of the eligible plants have received the award to date. Stringent eligibility requirements account for the relatively small number of plants receiving the honor in comparison with the great number working on war contracts.

Of the 1910 plants which have received the "E," 1188 were nominated by the Army and 722 by the Navy. A total of 1598 companies were represented, 1042 manufacturing products primarily for the Army and 556 for the Navy. The Army awards cover a period of approximately one year. The Navy awards extend over a two-year period and include the Navy "E," which was superseded a year ago by the joint Army-Navy award.

WAR MANPOWER COMMISSION REISSUES LIST OF ESSENTIAL ACTIVITIES

The War Manpower Commission reissued on August 17 its list of essential activities, including the amendments that have been made from time to time. In some cases slight variations in phraseology appear which aid in interpreting the list but do not represent any basic change of content. There are no changes except those which have been previously communicated to the industries affected and they have appeared from time to time as amendments to the original list.

Following are some of the 35 listings which are of particular interest to HPAC's readers. Additions and material revisions are shown in CAPITALS:

8. Construction: Highway and street construction; marine construction; construction of approved industrial plants, houses, hospitals, and military projects; repair of such facilities; and services necessary to complete such construction.

9. Coal Mining: The mining of anthracite, bituminous, and semi-anthracite coal; lignite, and peat, and the operation of breakers or preparation plants. Includes also removing overburden and other such activities preparatory to coal mining operations.

13. Production of Metal Shapes and Forgings: The manufacture of castings, die castings, forgings, wire, nails, chains, anchors, axles, pipe, springs, screws, bolts, tubing, stampings, pressings, structural shapes, and machined parts.

15. Production of Industrial and Agricultural Equipment: Power boilers, wiring devices and supplies; agricultural implements; electric lamps; storage and primary batteries; pumps, compressors, and pumping equipment; recording, controlling and measuring instruments and meters; conveyors, industrial cars and trucks; blowers, exhaust and ventilating fans; mechanical power transmission equipment such as clutches, drives and shafts; mechanical stokers; tools, files, and saws; plumbers' supplies; professional and scientific instruments, photographing apparatus, and optical instruments; and all equipment necessary to operate plants producing essential commodities.

22. Production of Stone, Clay and Glass Products: Scientific and industrial glass products; sand-lime, firebrick, and other heat resisting clay products; CHEMICAL lime; abrasive wheels, stones, paper, cloth and related products; asbestos products including steam and other packing, pipe and boiler covering; crucibles and retorts; GYPSUM BOARD; MINERAL WOOL (FOR INSULATION); porcelain electrical supplies; as well as parts of military apparatus.

24. Production of Finished Lumber Products: Cork products such as life preservers; storage battery boxes; insulating material; cars; matches; crutches; wood preservation activities; BUILDINGS, PORTABLE AND PREFABRICATED; WOOD BASE HARDBOARD. Includes also wooden parts of aircraft, ships, and other military equipment.

30. Heating, Power, Water Supply and Illuminating Services: Electric light and power, water and gas utilities; steam heating services; SEWAGE SYSTEMS; TREE TRIMMING FOR POWER AND COMMUNICATION LINES; WATER-WELL DRILLING.

31. Repair Services: Repair of: vehicles, such as bicycles, motorcycles, automobiles, buses, trucks; tires; typewriters and business machines; elevators; shoe repairing; SEWING MACHINES, radios; refrigerators; clocks and WATCHES; harnesses; tools; stoves; pneumatic tube systems; power laundry equipment; electric appliances and motors, engines, heating equipment; scientific, commercial and industrial weighing machines; farm and other industrial and scientific equipment; WELDING SERVICE; roofing, and electric, gas and plumbing and heating installations in domestic, commercial, and industrial buildings; BUILDING ALTERATION, MAINTENANCE AND REPAIR; blacksmithing; armature rewinding, locksmithing. It is intended that consideration be given only to individuals qualified to render all-around repair services on the types of equipment specified herein as required for the minimum essential needs of the community.

THE SHAPE OF THINGS TO COME

"Advertising budgets once used for the purpose of selling merchandise to the public may have to be applied widely in reverse to combat the wild and weird dreamworld products which uncontrolled and ill advised publicity is creating today in the minds of Americans," according to Gordon Rieley, vice president of the Bryant Heater Co.

Backing up his belief that manufacturers in the automotive, aviation, and building fields, as well as in his own industry, confront a problem demanding immediate action, Mr. Rieley already has assigned a portion of his company's advertising appropriation to the purpose of "straightening the thinking of a misguided public."

A recent Bryant advertisement, captioned Speaking of the Shape of Things to Come, illustrates a scholarly looking old gentleman pointing seriously to a blackboard on which he has drawn an action diagram which rivals some of Rube Goldberg's best classics. The copy begins: "Hold everything, Horatio! It's a bit early, don't you think, to predict the heating of homes by captive heat waves?

The Editor's Pages

Or furnaces fed by radio beam?" The copy continues by explaining how there will be new, improved heating, but produced by "sensible, down to earth engineering."

Mr. Rieley finds room for criticism in the stories circulated regarding developments which are far from ready for public use. He regards as too costly the general application of district heating by which an entire area of homes would be supplied by a central heating plant. It is his opinion that heating of buildings with electrical energy stored during offpeak hours is a method on which much study is needed before it can become practical. The sun heat boiler and the rumored use in corn growing areas of alcohol as a fuel were tabbed as subjects which still should be confined to the laboratories.

"None of us want to stand in the way of progress," concludes Mr. Rieley. "None of us want to delay any longer than necessary giving to Americans the better things that American genius can and will provide. However, unless we more intelligently use the powers of advertising and publicity which, in the past have served us so well, we will discover Mr. and Mrs. America demanding and expecting us to deliver merchandise that not even Superman could produce."

"FREON" PRODUCTION INCREASED

A new plant addition, which will make possible a 55 per cent increase in the productive capacity for "Freon-12" fluorine refrigerant now used also as the propellant in aerosol insecticides, was announced last month.

Construction of the addition, authorized by the War Production Board, will start immediately at Carney's Point, N. J., and the new capacity is scheduled to be ready by February 1, 1944. The demand for "Freon" has increased so that this latest and largest plant addition is announced even before a previously authorized increase in capacity has been completed.

This chemical has recently been selected for use as the propelling and dispersing agent in the new aerosol insecticide developed by government scientists to combat the malaria carrying mosquito at tropical fighting fronts.

"Freon" fluorine compounds are safe for food refrigeration and are applicable to all types of domestic and industrial air conditioning and refrigeration equipment. These compounds are produced by Kinetic Chemicals, Inc., which is jointly owned by E. I. du Pont de Nemours & Co. and General Motors Corp.

HEATING SURFACE ORDER REVISED

A complete revision of the extended surface heating equipment order, L-107, announced July 28 by the War Production Board, restricts distribution of extended surface heating equipment to "approved orders"—those which specify a delivery date, are rated AA-5 or better, or which are for repair parts.

By establishing a provisional scheduling procedure, L-107 provides for a better distribution of orders among the various manufacturers in the event that bottlenecked conditions occur during the peak demand season.

Schedule I to L-107 provides an extensive simplification program for the industry. The number of sizes and types of extended surface heating equipment has been reduced.

Extended surface heating equipment means any heat transfer element or any apparatus employing a heat transfer element, designed and constructed for space heating or for industrial heating or drying and using steam or hot water as the heating medium. It includes, but is not limited to, unit heaters, unit ventilators, convectors, blast heating coils, and special heating coils. It does not include gas or other direct fired unit heaters, any cooling equipment or any critical heat exchangers (covered by L-172).

OPTICAL MANUFACTURER DEPENDS ON CONDITIONING

The accurate gunfire of America's fighting ships in the Far East and the devastating effects of American artillery in North Africa are due in large measure to the utilization of modern air conditioning equipment in the plant of Bausch & Lomb, optical manufacturers.

Recently, Betlem Heating Co., dealer for Carrier Corp., completed the third installation of air conditioning equipment in the binocular assembly room of the optical manufacturer. Air conditioned rooms are required for the preparation of optical parts of binoculars because dirt cuts the light gathering properties of the prisms and lenses. In cementing the lens element, the room air must be scrupulously clean in order that the balsam shall not be contaminated. Also, the temperature must be held within close limits both for applying the balsam and for drying.

Air conditioning is also being called on at Bausch & Lomb to aid in high precision work in the manufacture of range finders and height finders, essential components of modern warfare. In space where these products are manufactured, assembled and tested, air conditioning equipment reduces heat that is generated by motors and people, eliminating danger of expansion or contraction of delicate metal parts by maintaining constant temperature. Likewise it controls humidity to prevent corrosion caused by perspiration on fingers.

In the assembly of lenses in microscopes, air conditioning is used to dehumidify the air between the assembled lenses so that they will not fog up under the varying temperature conditions of field use. Absolute dust control is required because a speck of dust on a range finder, for example, might look like a distant airplane to the observer.

Polishing lenses is another delicate operation which calls upon air conditioning to help insure perfection. For the polishing process, lenses are mounted on wax and any change in the wax, either softening or hardening, might cause inaccuracies. Consequently, it is important that the wax mountings remain the same during polishing, and air conditioning insures against the possibility of changes.

MONTHLY INVENTORY REFRIGERANT REPORTS

Monthly inventory reports as required by conservation order M-28 (chlorinated hydrocarbon refrigerants) must be made regardless of whether the refrigerants are held by owners for their own use or for resale, the War Production Board said July 29 in issuing interpretation 1 of the order.

The inventory report must show the aggregate quantity in the owner's possession, including stocks of less than 500 lb located at various places if the owner's total stock is more than 500 lb. It must include all amounts not actually being used in refrigerating or air conditioning systems.

M-28 prohibits delivery of chlorinated hydrocarbon refrigerants for use in or for resale for use in systems of the type described in "list B." The interpretation points out that a manufacturer may not charge any such system before delivery nor deliver the refrigerants separately to be used in charging the system. He may, however, deliver systems which had already been charged on the effective date specified in "list B."

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Published monthly by the Keeney Publishing Co., 6 N. Michigan Ave., Chicago 2. Telephone: State 6916/ Subscriptions: U. S. possessions, Canada, Mexico, Central America, South America, $2.00 per year; foreign, $4.00. Current copies, U. S. and possessions, 25c each, back copies 50c each. January, 1943, issue, $1.00 per copy/ Member of Audit Bureau of Circulations and Associated Business Papers, Inc./ Copyright, 1943, by the Keeney Publishing Co.

IN THIS ISSUE

Volume 15 September, 1943 Number 9

The Editor's Pages (news and comment).....front section 65

Women in the Air Conditioning Industry, by Margaret Ingels.. 447

The Design of Steam Transmission Piping, by Arthur McCutchan 450

Decentralized Air Conditioning Serves Big Aircraft Factory ("Open for Discussion")..... 456

Standardized Heating and Ventilating Equipment for Ships ("Open for Discussion")..... 458

Outlines Criteria Used to Decide Oil Conversions..... 460

Measuring the Flow of Fluids, by William Goodman..... 461

How Much of My Fuel Should I Have Used?..... 464

Sam Lewis' Page—High Temperature of Condensate Causes Trouble in Factory Heating..... 465

Users of Less Than 10,000 Gal of Oil Not Required to Convert.. 466

Recent Amendments to Fuel Oil Rationing Order..... 466

Portable Pipe Line Helps Win the War..... 467

Converting from Oil to District Steam, by L. W. Mauger..... 468

Boiler Water Treatment, by Kalman Steiner..... 471

Conditioned Air Can't Go On the Air at Hollywood Radio City, by Harry C. Alber..... 476

A History of Piping, by M. A. Hasselmann..... 477

Acres of Air Conditioning (new aircraft engine plant), by H. E. Ziel..... 480

Overfire Air Jets Effective for Smoke Elimination..... 481

Testing Toxic Atmospheres, by N. R. Bernz..... 482

Equipment Developments.....back section 135

Trade Literature.....back section 146

What Temperature Can Be Maintained Under Fuel Oil Rationing? ("Open for Discussion").....back section 156

Text of Newly Amended Refrigerant Order M-28....back section 168

Useful Information.....back section 173

Coming Events.....back section 182

Index to Advertisers.....back section 186

Journal Section of the American Society of Heating and Ventilating Engineers

50th Annual Meeting..... 485

Discoloration Methods of Rating Air Filters, by Frank B. Rowley and Richard C. Jordan..... 487

Fuel Conservation Possibilities Shown by Survey of Present Status of Heating Facilities, by K. C. Richmond..... 495

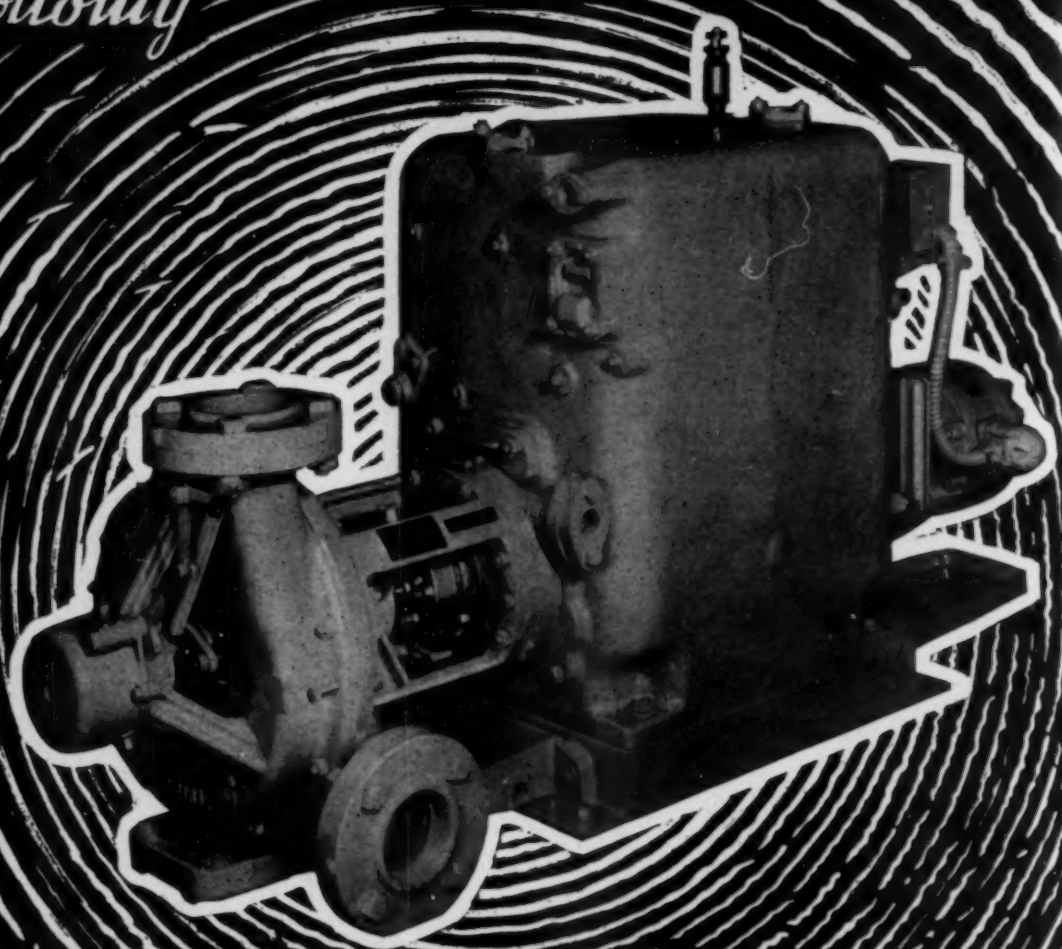
Members on Active Duty..... 499

Candidates for Membership..... 501

Candidates Elected..... 502

Officers, Council, and Committees..... 503

Centralized Heating Economy



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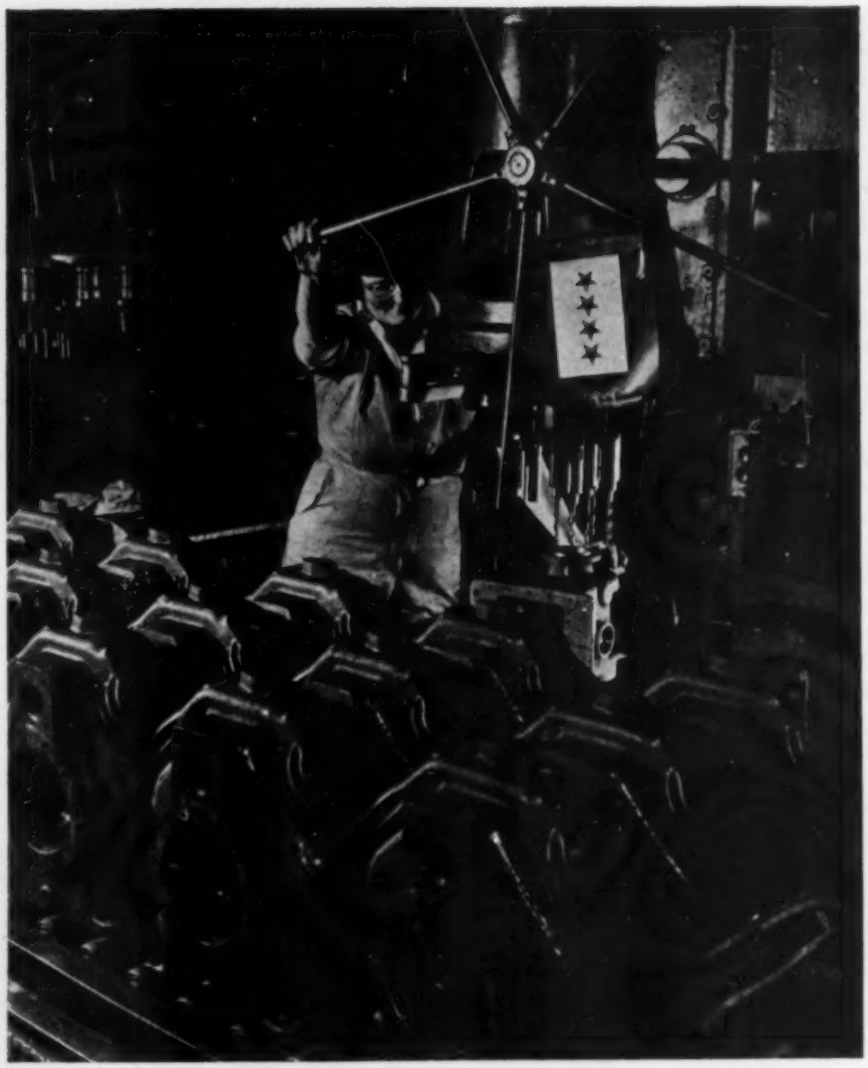


Mrs. Jane Hopkins works at a multiple drill press used in the manufacture of reciprocating refrigeration machines

Women in the Air Conditioning Industry

By Margaret Ingels

MANY OF the articles about women in war industries are written by men. They tell of the fine cooperation of the women on the production lines or drafting boards, and in the laboratories. The special training given women to equip them for men's jobs has received the attention of production managers, vocational consultants, and technical school teachers. Aptitudes, personality, and health of individual women have been analyzed to select the right person for the right position. The entire subject has been analyzed, employment schedules set up, working standards defined, and salary brackets fixed—all with the goal of maintaining maximum production schedules. The general welfare and contentment of the women employed are goals which must be reached if production schedules are to be realized. But what does the woman who is employed during wartime feel? What are her reactions to being a part of the vast army known as "womanpower"?

It is easy to imagine that the woman war worker's thoughts, satisfaction, and ambitions are as diversified as those of the man who formerly held the job that she is now performing. However, one predominating thought prevails with

all men and women workers. Each —consciously or unconsciously—enjoys the privilege of working.

Many women who are now working in industry have had new horizons opened up for them. In some instances they are not working any harder in the factory nor putting in longer hours than they once did in home making. Even though the job on the production line may be one that is considered monotonous and repetitive, it offers a new experience to the woman who has had only housework to do. The war job offers a chance for "meeting people" that is not overlooked by many of the women when accepting employment in a war plant. The companionship of fellow workers is a pleasant contrast to the loneliness of housework. In the case of women formerly unemployed, the opportunity to make money is an incentive. And a great many of them work with the knowledge that the rubber boat they helped to make may save a husband, or that the bullet they helped to produce may aid a son.

It is commendable that much praise and recognition has been given to women war workers, but to each individual the chance to express herself in a field new to her, where she has companionship, remuneration, and a feeling of usefulness in doing a big job provides her with great satisfaction. This is true whether the work is in the munitions or the air conditioning industry.

The Type of Work Women Are Doing

The type of work which women can and are doing in the air conditioning industry is represented by the positions formerly held by men and now being held by women in Carrier Corp. They vary from laboratory assistants, draftsmen, elevator operators and mail girls, to welders, solderers, inspectors, and shippers.

The training the women receive for the work they are doing with Carrier varies from welding and inspection classes given by the company or in local vocational high schools to instruction from fellow workers when starting the job.

The satisfaction of the women employees in their work is well described (with gestures) by one of the men workers: "She moves the lever over—does not swing it fast—stays put and by constant attention to the work does almost as much as a man doing the same work but doing it with much gusto!" There is no fair way to compare the amount of work done by women in the plant and that done by skilled workers, as the women have not had the long experience in the trade that the men whose positions they now hold have had. The women are very adaptable to the work and are doing better than was at first hoped they could do.

The women who are doing men's work at the Carrier Corp. represent wide ranges in ages, educational advantages, and economic status. Some are girls in their early twenties, others are older, one even being a grandmother. Several are professional or university graduates. Some need the money they earn to supplement family incomes which have been reduced by the menfolk being in the armed services. Others with economic independence welcome a job as an opportunity to serve their country.

A few descriptions of the woman war worker at Carrier will illustrate the types of jobs women are doing in the air conditioning industry and the kinds of women who are doing them.

With previous experience in a manufacturing plant, followed by many years of housekeeping, and a course in machine shop practice, Mrs. Jane Hopkins is working at a multiple drill press used in the manufacturing of reciprocating refrigerating machines. Mrs. Hopkins, who has been with Carrier for a year, has three sons and a son-in-law in the Army and a daughter in the WAC.

In investigating possibilities of

Mrs. Carlton F. Phelps, a skilled welder, helps produce vital war material

Mr. and Mrs. Nelson Stoffel pose for an unusual family photograph

employment in a war plant, a vocational counsellor suggested to Mrs. Carlton F. Phelps that she might try welding. She took a course and in the prescribed time passed the Army Air Corps welding test, which requires high skill. Mrs. Phelps is now working on vital war products. She had not previously been employed.

When Mrs. Nelson Stoffel—whose husband has been a welder for 29 years, the last five of them at the Carrier plant—learned that women welders were being employed by Carrier, she decided she would like to be one of them. After taking a course in welding given by the company and successfully meeting all the tests, she began work on welding pieces for refrigeration units for the Navy. Mrs. Stoffel takes great delight in being able to discuss striking an arc, making a bead, and all the other technicalities involved in the welding process. Prior to the welding job, Mrs. Stoffel was not employed in industry.

There are many other cases which might be cited of women workers in air conditioning, including those who are serving as laboratory assistants and draftsmen. Each is an interesting story but they all have the same ending. The women are doing a good job, doing it pleasantly and conscientiously, and are receiving a satisfaction which comes with doing work well.

The Woman Worker After the War

What the end of the war will mean to the woman war worker cannot be guessed. Many will no doubt return to home making. Others may have acquired such a liking for industrial occupation, or need employment for economic reasons, that they will want to continue to be a part of the air conditioning industry. If there is room for them after the men return from the fighting fronts, there is reason to believe that they will be satisfactory workers in peacetime as in wartime. It is hoped that the present women war workers who would like to stay in the air conditioning industry may have the opportunity.

It is not without personal feeling that I write on the privileges of being a woman war worker and express the hope that opportunities for women in the air conditioning field will be available to them after the war. It was during World War I that a position in the air conditioning industry was made available to me—a woman engineering graduate. It was an opportunity that probably would not have been mine except in wartime.

It was the Carrier Corp. which gave me the opportunity for a wartime job in 1917. The air conditioning field was open to women following World War I, as evidenced by the American Society of Heating and Ventilating Engineers having two women members as early as 1918. Helen Innis, one of the two, will long be remembered for her work in the field, specializing in heating.

The work which it has been my privilege to do in wartime, peacetime, and again in wartime has brought many satisfactions to me. After about 59,000 "woman hours" of working in the air conditioning industry I feel a justification for claiming to be a part of so great an industry and am proud to be identified with the corporation which employed a woman engineer 26 years ago.

The Feminine Touch

Many magazines are featuring the theme "womanpower in industry" this month. Thanks to Miss Ingels, this posed no problem to the editors; holder of the M.E. degree, engineering editor of Carrier Corp., and with 59,000 "woman hours" of working in the air conditioning industry to her credit, she is eminently qualified to write on the subject and adds a most welcome "feminine touch" to our pages.

Miss Ingels tells here why women work, why they like to, and what and how they're doing on jobs formerly held by men. She concludes by expressing the hope that the woman war worker who wants to stay in the air conditioning industry may have an opportunity to do so after the war.

The Design of STEAM TRANSMISSION PIPING

Arthur McCutchan Explains Factors to Consider in Choosing Between Large or Small Pipe Size

WHILE IT is not possible to establish hard and fast rules for the design of steam transmission lines—because each line must be tailored to fit the particular service conditions—there are a number of problems common to all such lines. These problems involve determination of pipe size and wall thickness, selection of insulation, calculation of line losses, provision for thermal expansion, and the like. The author has had occasion to consider these problems in the design of a number of steam transmission lines for proposed steam sales projects and for several long heating and process steam lines.

The purpose of this article is to discuss the factors entering into the solution of these inter-related problems and to present tables which facilitate the design of steam transmission lines. In order to demonstrate the use of these tables two lines—a normal pressure loss, and a high pressure loss steam transmission line—are assumed and the conditions responsible for the use of each are described.

Provision for Thermal Expansion

The method of providing for thermal expansion whether by directional changes of the line, use of slip expansion joints, conventional expansion bends, or expansion loops made up of fittings and straight lengths of pipe determines the type of expansion problem which must be solved. For illustrative purposes six possible types of line constructions are shown in Fig. 1 for the two steam transmission lines considered herein:

Type 1—Line installed above ground consisting of a 90 deg bend or elbow with tangents providing for expansion by directional change.

Type 2—Line installed in conduit (or tunnel) or above ground using slip joints.

Type 3—Line installed in conduit or above ground using conventional expansion U bends.

Type 4—Line installed in conduit or above ground using conventional double offset expansion U bends.

Large or Small?

The solution of an engineering problem usually lies in the choice of the proper method from several possibilities. In the design of steam transmission piping, a fundamental question is that of a small diameter line with comparatively high pressure drop as against a larger diameter line with a smaller drop. That's the subject so ably covered by Mr. McCutchan, engineer, engineering div., The Detroit Edison Co. The first part of his article appeared in the August HPAC, and the second and concluding part is published this month.

Problems involved in the design of steam transmission lines are discussed in this article with reference to a so-called "normal pressure loss" and a "high pressure loss" line. Each line is designed to accomplish the same purpose; that is, to supply the same quantity of steam at approximately the same final condition.

Which type of line is finally selected for a given installation will depend upon a number of factors—particularly cost—which are not considered in this article, but the apparent advantages of the smaller high pressure loss line should be given careful consideration. The advantages as developed here are less tonnage of pipe, elimination of condensate loss during normal operation, reduction in heat loss of line, and reduction in forces on anchors. The number of expansion loops or bends required to absorb thermal expansion of the smaller, slightly higher temperature line is the only apparent disadvantage over the larger normal pressure loss line. Even this disadvantage is offset by the reduction in cost and in the overall heights of bends required.

The discussion of the method of providing for thermal expansion of these two types of transmission lines given this month is carried through in detail in order to illustrate the use of the expansion bend tables. These tables are believed to fill a need for a means of selecting conventional expansion bends with a minimum of computation.

Type 5—Line installed in conduit or above ground using wide expansion loops made up of welding elbows and straight pipe.

Type 6—Line installed in conduit or above ground using square expansion loops made up of welding elbows and straight pipe.

Type 1—90 Deg Bend or Elbow with Tangents

From Fig. 1, it is evident that the assumed 1400 ft straight line distance between plants represents the hypotenuse of a 60 deg right triangle. If it were necessary to run the lines along the legs of this triangle because of right-of-way difficulties or interferences, the directional change would be more than adequate to absorb the expansion. Only an overhead line was considered for this layout since such construction makes it practicable to support the line so that the 90 deg bend or elbow is free to move about 4½ ft from the cold to the hot position.

Since the dimensions of such a line are beyond the scope of most precalculated solutions the grapho-analytical solution given in the Piping Handbook, by Walker and Crocker, can be used to advantage for this problem. The bending stresses and reacting forces were found to be so low that they can be neglected in this particular problem. Approximately 40 per cent more pipe, insulation, etc., would be required for this roundabout line than if the line were run the shortest distance between plants.

Type 2—Expansion Slip Joints

The use of slip joints makes it possible to install the line either in a conduit or above ground, and to use the minimum length of pipe, amount of insulation, etc. The expansion problem consists simply of computing the overall change in length from installation to operating temperatures and dividing by

the amount of elongation which can be taken up by the type of slip joint chosen. The traverse or free movement of the sleeve from its extreme positions varies from about 2 to 12 in. per end depending upon the make and style of joint.

The straight line distance between the ends of the line has been assumed as 1400 ft. The expansion per 100 ft between installation temperature, assumed as 60 F, and the respective operating temperatures may be found from tables of thermal expansion, such as Table 1 on p. 594 of the Piping Handbook. The thermal expansions in inches per 100 ft from 60 F to the operating temperatures of the two lines considered in this article are shown in the following tabulation:

Thermal expansion of pipe in inches per 100 ft

	Normal pressure loss line, 16 in.	High pressure loss line, 8 in.
Operating temperature, F	350	420
Elongation to operating temperature, in. per 100 ft	2.945	3.566
Elongation to 60 F, in. per 100 ft	0.593	0.593
Difference, in.	2.352	2.973

The overall elongations of these two 1400 ft transmission lines are 32.93 in. and 41.62 in., respectively. Assuming that double end slip joints having traverses up to 12 in. per end are available, two such joints should be able to care for either line. The line should be anchored at the middle and at each end. The double end slip joints situated at the quarter points also are anchored. If the lines are properly supported and guided, the above anchorages insure that each slip end cares for its assigned portion of the total elongation. Anchors must be designed to resist the force due to pressure tending to pull the joint apart and to overcome friction of the expansion sleeve in the stuffing box. One manufacturer of such joints recommends an allowance of 2000 lb per in. of sleeve diameter for packing gland friction.

For the 16 in., 3/8 in. wall, normal pressure loss line, the force on the anchor, neglecting friction of supports which can be made quite small, is found as the sum of the following:

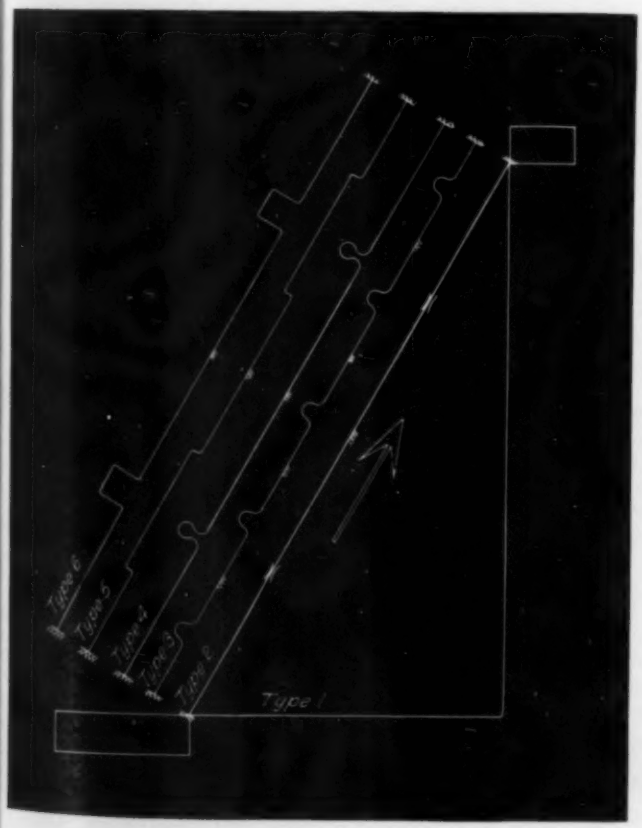


Fig. 1—Alternate methods of providing for thermal expansion of 16 in. steam transmission line. Expansion bends and loops are shown two times the scale of the lines

Internal pressure force: 120 psi pressure × 182.6 sq in. internal cross sectional area	= 21,900 lb
Packing gland friction: 2000 lb per in. × 16 in.	= 32,000 lb
Total	53,900 lb

The anchor forces for the 8 in. high pressure loss line, despite the higher line pressure, are considerably less than for the larger normal pressure loss line.

Internal pressure force: 300 psi pressure × 50.0 sq in. internal cross sectional area	= 15,000 lb
Packing gland friction: 2000 lb per in. × 8 in.	= 16,000 lb
Total	31,000 lb

Type 3—Expansion U Bends

While a number of relatively simple chart solutions are available for checking the adequacy of expansion U bends, they all require a certain amount of calculation to find the expansion to be cared for and the solutions, in general, are of a trial and error type. The overall lengths of pipe and corresponding reacting forces for expansion U bends of various radii may be found directly from the accompanying Tables 3 and 4. The description of the use of these tables and methods of adjusting for bending stresses and credit for cold spring are given in connection with the tables.*

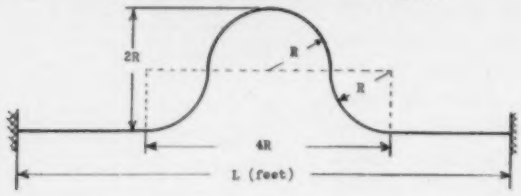
For the 16 in. normal pressure loss line, which has an operating temperature of 350 F, the overall length of pipe permissible for an expansion U bend having a radius of six times the nominal pipe diameter is found by interpolating between 300 F and 400 F in Table 3 as 161.5 ft. This length, as stated in Table 3, is based on a bending stress of 12,000 psi and no credit for cold spring.

The combined bending and longitudinal pressure stress permitted by the Code for Pressure Piping (ASA B31.1—1942) for outdoor steam distribution piping made of grade A, low carbon, seamless pipe for an operating temperature of 350 F is $\frac{3}{4}$ ($S_{150\ F} + S_{350\ F}$) = $\frac{3}{4}$ (12,000 + 11,040) = 17,280 psi. S is allowable stress, psi. [See Table 2, p. 403, August HPAC, for S values.]

The longitudinal pressure stress is found by dividing the product of the internal pressure and the in-

*Permission to reproduce Tables 3, 4, 5, and 6 and all explanation used in connection therewith is reserved by Walker and Crocker and the publishers of the Piping Handbook.

Table 3—Expansion U bends, all pipe thickness schedules. Overall lengths of pipe in feet permissible with expansion U bends of various radii. Table is based on Fig. 40, Piping Handbook, by Walker and Crocker, third edition, p. 662 (McGraw-Hill Book Co., Inc.). Permission to reproduce this table is reserved by the authors of the Piping Handbook. Pipe is assumed to be installed at 60 F. No credit is taken for cold spring in establishing tabulated pipe lengths. See text for method of adjusting lengths for bending stresses above or below 12,000 psi and to take into account partial or full credit for cold spring. Lengths are based on values of K and β for schedule 80 pipe but are sufficiently accurate for all pipe thickness schedules. K is the rigidity multiplication factor and β is the stress multiplication factor for curved pipe



Nominal pipe size, in. d_n	$\frac{R}{d_n}$	Radius of bend, in. R	L=Overall length of pipe in feet permissible with expansion U-bends of radius indicated (based on maximum longitudinal bending stress of 12,000 psi) 200 F	300 F	400 F	500 F	600 F	700 F	800 F
	6	12	28.6	15.9	10.8	7.9			
2	8	16	45.8	25.7	17.6	13.1			
	10	20	65.0	36.5	24.9	20.3			
	6	15	37.0	20.6	13.9	10.4			
2 1/2	8	20	59.5	33.3	22.9	17.3			
	10	25	83.5	47.5	31.7	24.5			
	6	18	46.7	26.1	17.5	13.2	10.7		
3	8	24	72.0	40.3	26.1	20.6	16.7		
	10	30	102.0	58.5	40.0	31.0	25.0		
	6	24	67.0	37.5	25.6	19.0	15.3		
4	8	32	100.0	57.2	39.6	29.6	23.7		
	10	40	141.0	80.0	55.0	42.5	34.6		
	6	36	100.7	60.0	41.2	30.4	24.1		
6	8	48	158.3	90.5	61.7	46.7	37.1		
	10	60	207.0	118.0	81.0	63.0	51.0		
	6	48	150.0	84.2	58.0	42.9	34.6		
8	8	64	221.0	124.2	86.7	66.2	53.3	44.2	
	10	80	301.0	170.0	116.0	88.0	71.0	58.0	
	6	60	200.0	112.1	72.1	57.9	45.8	38.7	
10	8	80	297.0	167.2	115.7	86.7	69.2	59.2	51.7
	10	100	400.0	225	155.0	120.0	96.0	83.0	72.0
	6	72	243.0	136.8	93.3	70.0	55.8	47.5	40.8
12	8	96	357.0	201.0	139.2	104.2	84.2	71.7	63.0
	10	120	485.0	282.0	190.0	143.0	116.0	100.0	85.0
	6	84	290	168.2	115.2	86.3	69.2	57.9	51.7
14	8	112	416.0	243.0	171.6	130.0	104.2	89.2	77.5
	10	140	615.0	345.0	234.0	178.0	144.0	127.0	106.0
	5	80	252.2	147.1	100.3	74.6	59.6	50.4	43.8
16	6	96	327.0	191.0	132.0	98.8	79.7	67.5	58.7
	7	112	392.0	225.0	157.0	118.0	95.0	80.0	70.0
	5	90	289.0	168.4	115.5	85.8	68.4	57.8	50.4
18	6	108	378.0	220.0	152.2	114.2	91.7	84.8	74.7
	7	126	460.0	258.0	175.0	133.0	106.0	90.0	79.0
	5	100	318.0	185.5	127.5	94.2	75.8	63.5	55.0
20	6	120	414.0	241.5	169.2	126.3	101.6	86.8	75.4
	7	140	488.0	280.0	195.0	148.0	116.0	100.0	88.0
	5	120	375.0	218.5	187.5	115.5	92.5	78.0	68.0
24	6	144	517.0	302.0	213.0	156.6	126.3	107.2	94.2
	7	168	610.0	357.0	252.0	195.0	162.0	136.2	120.0

ternal cross sectional area of the pipe by the cross sectional area of the pipe metal. For the 16 in., 3/8 in. wall pipe and 120 psi pressure the longitudinal stress due to internal pressure is (120 × 182.6) ÷ 18.4 = 1190 psi. The permissible maximum bending stress for grade A seamless pipe at 350 F is therefore 17,280 — 1190 = 16,090 psi.

The length of 161.5 ft found from Table 3 is adjusted to this maximum permissible bending stress by multiplying by the ratio of the stresses, as follows: 161.5 × (16,090/12,000) = 216 ft.

In addition to the adjustment for stress, an adjustment to take credit for cold spring may be made. Where pipe is cut short by 50 per cent or more of the computed expansion and sprung into position, the Code for Pressure Piping permits a maximum credit of one-third the computed expansion. The adjustment of lengths to take this maximum credit for cold spring into account is simply effected by multiplying by 1.5.

The overall length of pipe permissible with a bending stress of 16,090 psi and maximum credit for cold spring is 216 × 1.5 = 324 ft. Dividing the total line length by this length per bend it is found that five bends would be required: 1400/324 = 4.33, and the next larger whole number = 5. The final overall length per bend is then 1400/5 = 280 ft.

The actual bending stress is found by dividing by the cold spring multiplier of 1.5 previously used: 280/1.5 = 186.5.

Solving the expression

$$\frac{X}{12{,}000} = \frac{186.5}{161.5}$$

$$X = 13{,}820 \text{ psi}$$

The reacting forces for a 16 in. expansion U bend having a radius of six times the nominal diameter operating at 350 F and absorbing expansion of 161.5 ft of pipe as given in Table 3 are found by interpolating between 300 F and 400 F in Table 4 as 12,350 lb. Since these forces were based on lengths corresponding to a stress of 12,000 psi and schedule 80 pipe, they must be adjusted to the actual conditions as follows: 12,350 × (13,820/12,000) × 562/1156 = 6910 lb, in which 562 = moment of inertia of 16 in., schedule 30, 0.375 in. wall pipe, and 1156 = moment of inertia of 16 in., schedule 80, 0.843 in. wall pipe. It should be noted that no adjustment of forces is necessary because of taking credit for cold spring since the net amount of expansion provided for remains constant, the slightly greater flexibility of the longer lengths of pipe between bend and anchor points resulting in only a minor reduction in forces which may be neglected.

Actually, since the reactions of consecutive spans oppose each other, this reaction would only need be fully provided for at the extremities of the line. Because of unequal flexibilities of successive bends and unequal heating of adjacent spans during warming up of the line it is good practice to provide anchor points between spans as shown on Fig. 1. Although intermediate anchors are not strictly essential, they give better control over expansive move-

ments of the line and, because the distances between anchors are relatively long, do not appreciably reduce the flexibility of the line.

A similar solution for the 8 in. high pressure loss line shows that a total of seven expansion U bends, having a radius of 10 times the nominal diameter, would be required. The bending stress would be 14,500 psi and the reacting forces only 1970 lb. The overall height would be a little over 13 ft.

Type 4—Double Offset Expansion U Bends

The number of double offset expansion U bends required for the 16 in., schedule 30, 0.375 in. wall pipe line is found from Table 5 in exactly the same way as just described for the expansion U bends. The much greater ability of double offset expansion U bends to absorb expansive movement makes it necessary to use only two bends having a radius of six times the nominal diameter in place of the five expansion U bends which were found to be necessary. The overall height of such a bend is over 27 ft as against 16 ft for the expansion U bend. The reacting forces are less than 60 per cent of those for the expansion U bend and only one intermediate anchor need be considered.

In the case of the 8 in. high pressure loss line a total of four double offset expansion U bends having a radius of seven times the nominal diameter probably could be used, although the bending stress of 15,880 psi is about 4 per cent higher than permitted in the Code for Pressure Piping for this particular condition. The reacting forces are found to be only 1800 lb and the overall height of the bends about 16 ft.

Type 5—Wide Expansion Loop Made of Elbows and Straight Pipe

The wide expansion loop made up of welding elbows and straight pipe takes full advantage of the inherent flexibility of the straight pipe and of this method of construction. Provision for thermal expansion for the 16 in. nominal pressure loss line consists in the case of type 5 of offsetting the pipe line about 7½ ft on either side of a centerline. The optimum condition† requires that the width of the bend be equal to the sum of the distances between the bend and the anchor points, but a width one-half of this optimum width gives quite acceptable results.

A design chart for expansion loops** affords a convenient means of proportioning such expansion loops.

The 8 in. high pressure loss line requires four wide expansion loops with a height of about 8 ft or represents an offset of 4 ft on either side of the centerline.

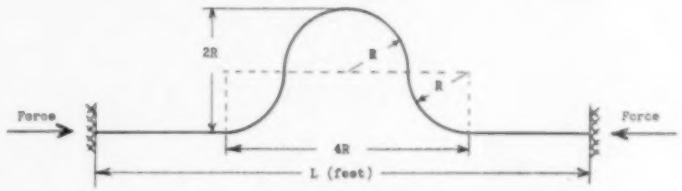
Type 6—Square Expansion Loop Made Up of Welding Fittings and Straight Pipe

The square expansion loops used in the type 6 construction require about 75 ft of additional pipe over

†The existence of an optimum shape for such expansion loops was first brought to attention in a paper by Sabin Crocker and the author: Frictional Resistance and Flexibility of Seamless Tube Fittings Used in Pipe Welding, Transactions, American Society of Mechanical Engineers, 1931, pp. 215-245.

**Tube-Turn Catalog and Data Book No. 111, p. 202.

Table 4—Expansion U bend, schedule 80 pipe. Reacting forces in pounds for expansion U bends of various radii when absorbing expansion of overall lengths of pipe given in Table 3. Table is based on Fig. 40, Piping Handbook, by Walker and Crocker, third edition, p. 662 (McGraw-Hill Book Co., Inc.). Permission to reproduce this table is reserved by the authors of the Piping Handbook. Reacting forces correspond to schedule 80 pipe of lengths given in Table 3. For reacting forces for schedule 40 or other pipe thickness schedules, multiply tabulated forces by the ratio of their respective moments of inertias. See text for method of determining forces for lengths adjusted for stresses above or below 12,000 psi



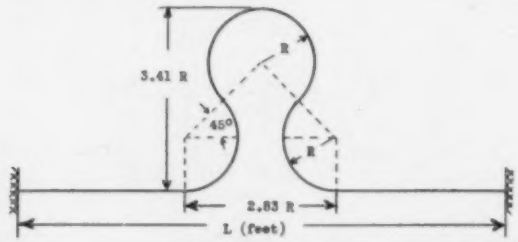
Nominal pipe size, in. d_n	$\frac{R}{d_n}$	Radius of bend, in. R	Reacting forces in pounds for Schedule 80 pipe expansion U-bends of radius indicated when absorbing expansion of overall lengths of pipe given in Table 3 which are based on a bending stress of 12,000 psi and no credit for cold spring						
			200 F	300 F	400 F	500 F	600 F	700 F	800 F
	6	12	458	504	550	615			
2	8	16	323	342	367	396			
I=0.6679	10	20	246	263	282	310			
	6	15	658	720	790	852			
2 1/2	8	20	467	500	535	576			
I=1.924	10	25	361	381	407	435			
	6	18	912	996	1090	1168	1260		
3	8	24	652	700	747	804	863		
I=3.894	10	30	502	532	570	597	632		
	6	24	1335	1435	1560	1700	1850		
4	8	32	950	1012	1078	1156	1232		
I=9.61	10	40	722	767	822	860	900		
	6	36	2550	2740	2930	3180	3420		
6	8	48	1800	1920	2050	2170	2330		
I=40.49	10	60	1325	1410	1516	1580	1670		
	6	48	3810	4080	4400	4770	5060		
8	8	64	2750	2920	3100	3290	3500	3680	
I=106.7	10	80	2100	2210	2350	2480	2580	2780	
	6	60	5650	6070	6620	6980	7500	7830	
10	8	80	4120	4360	4620	4910	5210	5330	5680
I=244.8	10	100	3180	3340	3540	3720	3890	4060	4270
	6	72	7680	8220	8880	9470	10,100	10,660	11,060
12	8	96	5590	5920	6320	6680	7060	7410	7630
I=475.1	10	120	4300	4570	4820	5020	5330	5460	5700
	6	84	9100	9670	10,350	11,060	11,700	12,000	12,900
14	8	112	6260	6640	7000	7450	7860	8130	8480
I=697.3	10	140	4870	5080	5470	5640	6120	6130	6340
	5	80	13,600	14,800	16,000	17,100	18,250	19,300	20,100
16	6	96	11,150	11,950	12,750	13,650	14,400	15,200	15,830
I=1156	7	112	9520	10,080	10,750	11,480	12,080	12,650	13,200
	5	90	16,980	18,400	19,860	21,400	22,700	23,700	25,000
18	6	108	14,000	14,950	16,000	17,000	18,100	18,500	19,250
I=1833	7	126	11,830	12,600	13,500	14,380	15,150	15,830	16,500
	5	100	20,900	22,600	24,400	26,200	27,900	29,300	30,600
20	6	120	17,150	18,280	19,500	20,900	22,400	23,100	24,000
I=2772	7	140	14,560	15,400	16,400	17,400	18,400	19,500	20,300
	5	120	29,700	32,100	34,300	36,900	39,300	41,200	43,100
24	6	144	24,300	26,000	27,700	29,600	31,400	33,000	34,300
I=5672	7	168	20,600	21,900	23,300	24,500	25,600	26,900	27,900

the shape used in type 5 for the 16 in. line, but the construction is otherwise fully as acceptable. Where width is limited by construction details, narrow and high expansion loops may sometimes be found necessary, but these do not utilize the flexure of the line itself to as good advantage as the square or wide type.

For the 8 in. line, four square bends would be required and would have heights and widths of about 19 ft.

It is evident from discussion of these various types of construction that there are a number of methods of providing for thermal expansion of a steam transmission line. Choice will depend upon particular conditions, cost determinations not considered herein, and individual preferences of designers.

Table 5—Double offset (540 deg) expansion U bend, all pipe thickness schedules. Overall lengths of pipe in feet permissible with double offset expansion U bends of various radii. Table is based on Fig. 41, Piping Handbook, by Walker and Crocker, third edition, p. 663. Permission to reproduce this table is reserved by the authors of the Piping Handbook. Pipe is assumed to be installed at 60 F. No credit is taken for cold spring in establishing tabulated pipe lengths. See text for method of adjusting lengths for bending stresses above or below 12,000 psi and to take into account partial or full credit for cold spring. Lengths are based on values of K and β for schedule 80 pipe but are sufficiently accurate for all pipe thickness schedules. K is the rigidity multiplication factor and β is the stress multiplication factor for curved pipe



Nominal pipe size, in.	$\frac{R}{d_n}$	Radius of bend, in. R	L=Overall length of pipe in feet permissible with double-offset expansion U-bend of radius indicated. (based on maximum longitudinal bending stress of 12,000 psi) 200 F	300 F	400 F	500 F	600 F	700 F	800 F	850 F
	5	10	55.8	31.2	22.5	16.6	12.9	11.2	10.0	9.2
2	6	12	72.0	40.6	29.1	21.7	17.5	15.0	13.3	12.5
	7	14	91.0	51.7	36.6	27.5	22.1	19.6	17.6	16.2
	5	12.5	72.5	40.6	29.3	20.8	17.1	15.0	13.3	12.1
2 1/2	6	15	93.8	52.5	37.1	27.9	22.9	19.6	17.5	15.8
	7	17.5	117.5	66.6	46.7	35.0	29.1	25.0	22.1	20.8
	5	15	91.3	51.3	35.9	27.5	22.1	18.5	16.7	15.4
3	6	18	117.5	66.3	46.3	36.0	28.3	24.2	21.7	20.4
	7	21	142.5	82.5	57.5	44.2	35.9	30.8	27.5	25.8
	5	20	131.2	73.3	50.8	38.3	31.3	26.7	23.3	22.5
4	6	24	168.2	96.0	66.3	50.5	40.8	35.0	31.3	29.6
	7	28	203.0	118.4	82.5	62.5	50.8	44.2	39.2	37.5
	5	30	206.5	117.8	81.2	62.5	50.4	42.8	38.3	36.2
6	6	36	245.0	151.5	105.7	80.0	66.4	55.8	50.0	47.5
	7	42	320	186.6	132.5	99.2	81.3	69.7	62.5	59.2
	5	40	285	166.6	114.2	86.7	70.8	60.4	53.3	50.9
8	6	48	362	211.5	149.2	113.2	92.4	79.2	70.5	67.5
	7	56	443	262	185.0	141.5	115.8	99.2	88.3	84.2
	5	50	372	216.5	152.5	115.8	85.0	80.8	70.8	67.5
10	6	60	462	270	190.0	149.0	122.5	105.0	93.3	89.3
	7	70	560	343	242	187.0	152.0	131.2	116.2	110.8
	5	60	438	256	181.0	139.5	114.2	97.5	86.7	82.5
12	6	72	560	330	232	181.0	149.2	128.6	114.6	109.2
	7	84	693	400	280	220	181.5	160.0	142.5	136.0
	5	70	542	316	172.6	159.2	142.0	121.2	107.5	101.6
14	6	84	687	400	283	219	179	159.2	141.6	133.2
	7	98	850	495	350	270	226.5	195.8	175.0	165.0
	5	80	624	365	258	196.0	161	138.2	122.5	116.2
16	6	96	782	456	322	249	205	179.2	160.8	153.3
	7	112	990	577	407	315	257	216	187	175
	5	90	697	407	287	222	180.0	156.8	140.0	133.5
18	6	108	940	548	387	299	243	204	183.3	175.0
	7	126	1110	647	457	353	287	240	206	193.0
	5	100	777	453	319	247	202	174	157.0	148.0
20	6	120	1010	588	405	305	248	209	181	170.0
	7	140	1230	717	507	392	320	267	228	214
	5	120	930	542	383	293	237	203.0	186.0	179.0
24	6	144	1270	742	523	380	311	262	227	213
	7	168	1580	922	642	496	403	340	291	273

Additional Data on Use of Expansion Bend Tables

A convenient solution for *conventional expansion bends* used with straight runs of pipe is furnished in Tables 3 to 6, which give the overall lengths of pipe cared for by various radii of bends and the corresponding reacting forces at different operating temperatures. Bends should be situated midway between anchor points, or at least within the middle third of the span, to agree with the assumptions made in preparing these tables.

The overall lengths given in Tables 3 and 5 for expansion U bends and double offset expansion U bends, respectively, are strictly accurate for schedule 80 (extra strong) pipe. But these tables may be used with reasonable accuracy for all pipe thickness schedules, since bending stress is independent of the wall thickness in straight pipe and only affected to a minor degree in the case of long radius bends by variations in the factors which correct for flattening of the circular cross section of curved pipe during flexure. For wall thicknesses less than schedule 80, the lengths given in Tables 3 and 5 are conservative, but not unduly so, because of the relatively long radius bends considered in these tables. For thicknesses greater than schedule 80, the lengths tabulated are slightly greater than found by a strict analysis, but not significantly so.

The lengths given in Tables 3 and 5 are based on an assumed maximum longitudinal bending stress of 12,000 psi and no credit for cold spring. If, for example, it is desired to permit a bending stress of 16,000 psi, it is only necessary to multiply the lengths given in the tables by 16/12. Where pipe is cut short by 50 per cent or more of the computed expansion and sprung into position, the Code for Pressure Piping permits a maximum credit of one-third the computed expansion. No adjustment of forces is necessary because of taking credit for cold springing since the net amount of expansion provided for remains constant. When adjusting for stresses above 12,000 psi, or when taking credit for cold spring, the resulting lengths are somewhat

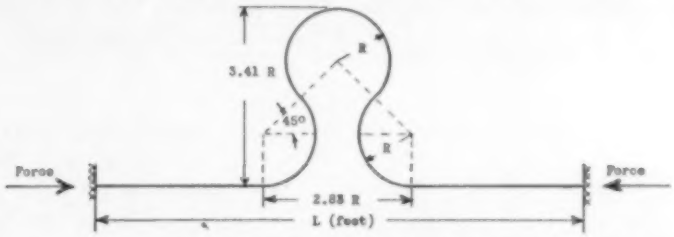
conservative, while for stresses below 12,000 psi the lengths thus found are slightly longer than given by a strict analysis. In neither case are the inaccuracies significant with the usual range of stress variation encountered.

The Code for Pressure Piping requires that for normal operating conditions the combined stresses due to bending and longitudinal pressure stresses shall not exceed three-fourths the sum of the *S* value for the piping material at room temperature and the *S* value at nominal operating temperature, but in no case shall the combined bending and pressure stress exceed 40 per cent of the specified tensile strength of the pipe material. Allowable *S* values for conditions encountered in saturated steam transmission lines are given in Table 2, p. 403, August HPAC. Reference should be made to the Code for Pressure Piping for allowable stresses for other materials and for higher temperatures and modifications required for cyclic loading conditions.

The reacting forces on the anchors for schedule 80 pipe bends corresponding to the overall lengths determined from the tables described in the foregoing are given in Tables 4 and 6 for expansion U bends and double offset expansion U bends, respectively. For pipe wall thicknesses greater or less than schedule 80, the tabulated forces should be multiplied by the ratio of their respective moments of inertias. The moments of inertia (*I*) for schedule 80 pipe used in calculating the forces given in Tables 4 and 6 are shown in these tables. The moments of inertia for other schedules of pipe thicknesses may be found from manufacturer's catalogs, the Piping Handbook, or the tables of pipe properties given in Heating, Piping & Air Conditioning for October and November, 1936, in the article on Use of American Standard Pipe Thickness Schedules, by Arthur McCutchan.

The tabulated forces are based on the lengths of pipe determined for a bending stress of 12,000 psi. The forces for the lengths obtained by adjustment for bending stress other than 12,000 psi are found by applying the ratio of the stresses in exactly the same manner as the adjustment for lengths. It should be noted that no adjustment of forces is necessary because of taking credit for cold spring, since the net amount of expansion provided for remains constant. The slightly greater flexibility of the longer lengths of pipe between bend and anchor points when lengths are adjusted to take advantage of cold spring only results in a minor reduction in forces, which may be neglected.

Table 6—Double offset (540 deg) expansion U bend, schedule 80 pipe. Reacting forces in pounds for double offset expansion U bends of various radii when absorbing expansion of overall lengths of pipe given in Table 5. Table is based on Fig. 41, Piping Handbook, by Walker and Crocker, third edition, p. 663 (McGraw-Hill Book Co., Inc.). Permission to reproduce this table is reserved by the authors of the Piping Handbook. Reacting forces correspond to schedule 80 pipe of lengths given in Table 5. For reacting forces for schedule 40 or other pipe thickness schedules, multiply tabulated forces by the ratio of their respective moments of inertias. See text for method of determining forces for lengths adjusted for stresses above or below 12,000 psi



Nominal pipe size, in. d_n	$\frac{R}{d_n}$	Radius of bend, in. R	Reacting forces in pounds for Schedule 80 pipe double-offset expansion U-bends of radius indicated when absorbing expansion of overall lengths of pipe given in Table 5 which are based on a bending stress of 12,000 psi and no credit for cold spring.							
			200 F	300 F	400 F	500 F	600 F	700 F	800 F	850 F
	5	10	299	316	331	347	365	375	384	393
2	6	12	251	264	275	287	298	309	316	320
I=0.8679	7	14	211	220	229	239	247	253	259	263
	5	12.5	455	493	503	530	550	565	578	592
2 1/2	6	15	367	385	402	418	432	443	457	467
I=1.924	7	17.5	306	319	332	345	357	366	376	379
	5	15	631	663	695	727	757	784	802	817
3	6	18	508	532	556	577	602	621	635	642
I=3.894	7	21	427	447	464	482	498	512	522	529
	5	20	903	952	1000	1048	1086	1122	1152	1162
4	6	24	745	778	815	847	873	900	922	932
I=9.61	7	28	628	652	678	707	728	747	762	770
	5	30	1720	1810	1910	1990	2070	2110	2160	2190
6	6	36	1420	1480	1540	1600	1660	1710	1740	1760
I=40.49	7	42	1200	1240	1280	1340	1380	1410	1440	1460
	5	40	2590	2720	2850	2970	3090	3180	3260	3290
8	6	48	2130	2230	2310	2410	2490	2560	2600	2630
I=105.7	7	56	1820	1890	1960	2030	2120	2150	2190	2200
	5	50	3850	4050	4230	4420	4640	4720	4840	4870
10	6	60	3190	3330	3460	3590	3710	3810	3870	3910
I=244.8	7	70	2700	2810	2910	3000	3100	3170	3240	3270
	5	60	5260	5520	5770	6000	6210	6400	6550	6600
12	6	72	4330	4530	4720	4870	5020	5170	5270	5320
I=475.1	7	84	3690	3830	3970	4080	4210	4300	4390	4430
	5	70	5920	6220	6720	6820	6950	7170	7300	7360
14	6	84	4870	5070	5270	5450	5620	5720	5860	5920
I=687.3	7	98	4080	4200	4380	4480	4560	4720	4790	4850
	5	80	7630	8000	8350	8670	8950	9220	9440	9570
16	6	96	6300	6520	6820	7080	7240	7420	7540	7630
I=1156	7	112	5330	5530	5720	5880	6060	6230	6390	6470
	5	90	9520	10,000	10,420	10,820	11,230	11,480	11,740	11,840
18	6	108	7920	8200	8500	8820	9090	9370	9540	9620
I=1833	7	126	6690	6960	7180	7420	7620	7830	8070	8170
	5	100	11,700	12,040	12,780	13,320	13,750	14,120	14,440	14,560
20	6	120	9600	10,000	10,400	10,800	11,180	11,520	11,860	12,000
I=2772	7	140	8180	8480	8780	9040	9320	9580	9840	9940
	5	120	16,600	17,420	18,140	18,960	19,600	20,200	20,500	20,650
24	6	144	13,860	14,250	14,780	15,350	15,920	16,380	16,810	17,050
I=5672	7	168	11,620	12,040	12,480	12,980	13,260	13,640	14,000	14,160

* * *

BUY WAR BONDS

* * *

"OPEN FOR DISCUSSION"

(Comment from readers on HPAC's articles)

Decentralized Air Conditioning Serves Big Aircraft Factory

IN THE August HPAC, under Open for Discussion, was printed some very interesting comment by O. W. Ott and W. A. Grant concerning my article Decentralized Air Conditioning Serves Big Aircraft Factory, which appeared in the July HPAC. Mr. Grant's comments are in line with the material he presented in the ASHVE Journal Section of the August, 1942, HPAC, entitled Air Conditioning of Blackout Plants, wherein the advantages of centralized refrigeration equipment were strongly emphasized. However, Mr. Grant is evidently not very familiar with the famous Southern California climate, so his latest remarks deserve some measure of refutation. Representing a company which manufactures large central station refrigerating equipment as well as smaller unitary equipment for decentralized plants, I have no axe to grind and have no reason to be other than neutral in any controversy over the relative merits of the two methods of air conditioning a blackout plant.

Source of Energy

Mr. Grant admits the higher first cost when using centralized chilled water refrigeration, but emphasizes the possible savings in operating and maintenance expense provided steam turbine drive is used for the refrigerating machines. When cheap electric power is not available, and the project must generate its own power for the entire plant, I can agree with Mr. Grant that the central refrigeration system with steam turbine drive may under certain conditions show up to advantage, economically, compared with the decentralized job. In any such comparison, the operating cost savings due to the use of steam turbine drive should be properly capitalized to offset the additional first cost. However, as Mr. Ott points out, with an abundance of cheap electric power available there is no object in putting an aircraft plant in the power business.

From an economic standpoint only, the prime consideration in choosing between a decentralized or a centralized cooling system is the source of energy available to the project. If committed to the purchasing of electrical energy for lighting and power requirements throughout the plant, as on the Douglas Aircraft job in Long Beach, then almost without exception the decentralized, direct expansion type of refrigeration system is best from both the standpoint of initial investment and operating cost. On the other hand, if cheap electric power is unavailable, and the project must generate its own power using steam boilers, turbo-generators, etc., then in most cases the steam turbine driven central refrigeration plant will show up to advantage economically despite its higher first cost.

It is perfectly possible to take most any design of air distribution for an aircraft plant of this type and change it radically so as to reduce the number of fan stations, the cfm per sq ft of floor area, the amount of ductwork (possibly running exposed ducts above the roof) etc., and still theoretically take care of the same cooling and heating loads. Having had experience with this line of attack on the Douglas job, I pointed out in my article that any comparison of initial costs between central station and decentralized air conditioning equipment for a given installation should be made with each having the same number of fan stations in order to have a fair comparison.

Reheating and "Recooling"

I have been a resident of Southern California for more than 10 years, and to a Southern Californian there is nothing surprising about cold nights and mornings with very warm afternoons in winter—or for that matter, even in summer. From observation of operating conditions at the Douglas plant and from discussions of conditions with the operating personnel, I would say that heating is used on about 50 per cent of the days in the year, and cooling in

Centralize or Decentralize?

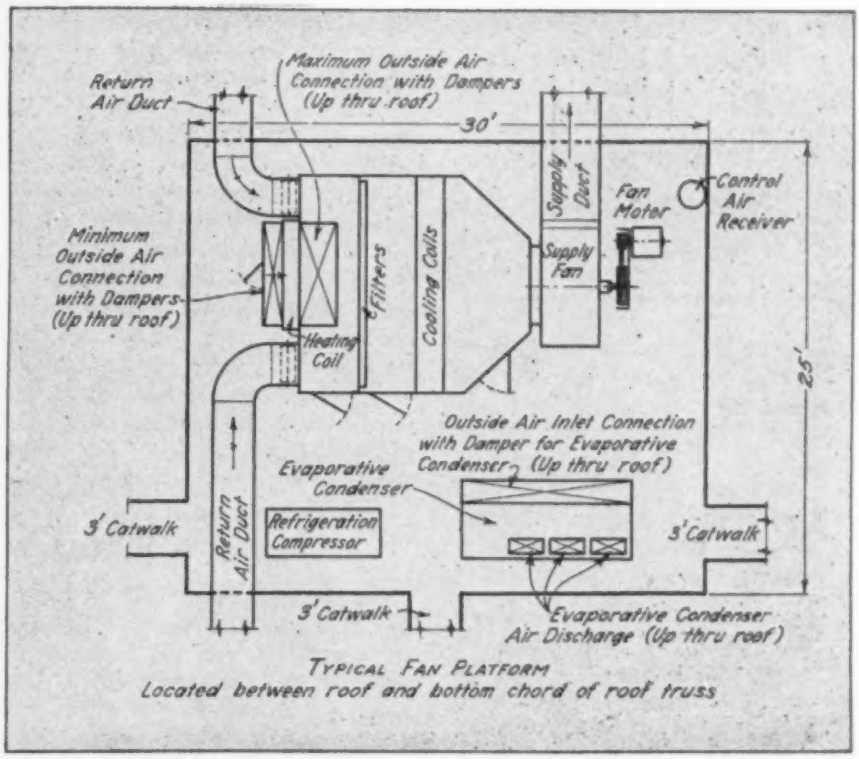
That is the question. At least, it's the question under consideration here. In the July issue, H. M. Hendrickson described the decentralized layout serving the big Douglas Aircraft plant at Long Beach, Calif. In August, W. A. Grant discussed decentralization vs. centralization of large air conditioning systems and argued for the latter. Here, Mr. Hendrickson comes back at him, carrying the banner for decentralization.

Time was when the air conditioning fraternity seemed to be primarily concerned with seeking to prove that air conditioning is usually advantageous and often essential in manufacturing plants. But that's been pretty well demonstrated by now; the vital importance of the battle of production has demonstrated in numerous cases that control of the air in factories is often as important as control of the air in combat zones.

The big question now involves the technique of achieving that control. Mr. Grant's and Mr. Hendrickson's comments cover a number of interesting phases of the problem.

some parts of the plant on about 75 per cent of the days.

Heating is required during the night and morning shifts most of the time during the fall and winter months. Along about 10 a. m. to noon, the combination of sun effect and internal load is usually sufficient to require the operation of a few refrigeration machines in each building at points where the internal load is heaviest. On the other hand, zone heating is often required because of opening of the large doors. As for reheat, there is none employed in this plant; and I stated at several points in my article that the controls were so interlocked that the cooling and heating could not operate at the same time on any one unit. However, with some buildings having as many as 26 independent refrigeration systems, you do have a considerable measure of zoning without reheat, since any of the systems could be cooling while the others are heating, or vice versa. With a central refrigeration system using the same piping system for the circulation of either hot or cold water as the season demands, such zoning is impossible. Mr. Grant mentions reheat as a possible solution, but reheat would only take care of summer operation, whereas "recooling" would be required in some zones during winter operation with the central system on hot water circulation. Duplicate piping systems, one for hot water and one for cold water, together with duplicate sets of coils in the air stream would accomplish the desired results. Such duplication, or even the addition of reheat, would aggravate the already bad first cost picture for the central refrigeration layout.



There are 168 unitary ventilation systems and 125 refrigeration systems serving the air conditioning requirements of the plant discussed herein

Chilled Water Temperature

I agree with Mr. Grant that initial water temperatures of 45 to 48 F are perfectly feasible for the chilled water circulating system from an engineering standpoint, provided sufficient water is circulated to limit the temperature rise through the system to 6 or 8 F. However, here again the first cost picture would be greatly aggravated as it would be necessary to circulate about twice as much water compared with a system designed for a 40 F initial water temperature and say, a 14 F water rise. The fundamental relationship,

$$\text{Tons of refrigeration} = \frac{(\text{Gpm})\ (\text{Temp. Rise})\ (8\tfrac{1}{3})}{200} = \frac{(\text{Gpm})\ (\text{Temp. Rise})}{24}$$

requires only a cursory inspection to show that a low initial water temperature and a fairly high temperature rise will give the smallest water circulation. Since the cost of water piping and water piping insulation is a major portion of the already high initial cost of a central refrigeration system, it is not economically sound to use high water temperatures at the expense of larger piping. Furthermore, it requires more pump horsepower to circulate the larger water quantities.

Operation and Maintenance

As to the operating and maintenance problem, I will say that Mr. Grant's ideas appeared to be correct during the first months of operation with an inexperienced operating crew. Having been quite closely connected with the development of the air conditioning at the Douglas plant from the early design period, throughout the construction of the original plant, and then during the construction of the subsequent addition, I have had an opportunity to observe the changing operating conditions and discuss their problems with various operating engineers. At first the maintenance appeared to present a tremendous problem, commensurate with Mr. Grant's ideas on the subject, and the operating personnel was decidedly out of proportion with the actual needs. Then, as experienced supervisors were obtained and the personnel trained, it was possible to eliminate the inexperienced and unnecessary personnel, and only then did the true requirements begin to take shape. I now understand that the operating crew is being reduced to 10 men per shift who make hourly inspections at each fan station. On some of the smaller buildings, one man may take care of several buildings. On the day shift only there are, in addition, three emergency service men and a supervisor. One emergency service man is for boiler and heating service, and the other two are for refrigeration. The latter also take care of the upkeep of the numerous process refrigeration units (such as rivet coolers) and the drinking water coolers throughout the plant. Besides the service

Control of the Air in Industry Is Helping to Win the Battle of Production

men, there is a filter cleaning crew of six men on the day shift who do nothing but maintain the thousands of air filters. The maintenance problem does not appear to be so difficult due to the fact that so many of the systems are identical, and now the labor turnover is very low.

Comparing with a central water cooling system, you would still have the same number of fan stations and could hardly get along with much less than 10 men per shift for a total of 168 stations. Also, the same filter cleaning crew would be required, providing the type of filters remained the same. In addition, the central refrigeration station itself would require one or possibly two men per shift, and this would not include emergency service. Actually, the central station job will have operating troubles also, and a repair crew of three men on the day shift hardly seems unreasonable with boilers, turbines, pumps, and equipment at each fan station requiring periodic adjustment and repair. Therefore, as I see it, the only operating savings with a central refrigeration setup compared with a decentralized job would occur when the cost of outside purchased electrical energy is prohibitive and the plant in question must generate its own power.

Construction Speed

But getting away from purely economic considerations, and looking at the picture in the light of the war emergency, we can make further interesting comparisons between centralized and decentralized refrigeration systems for air conditioning of large blackout factories for war industries. For the construction of any such plant situated within probable enemy bombing range, two of the major considerations are speedy construction, and minimum disruption of production in case of enemy bombing. On the Douglas job, it is doubtful if large central station refrigeration equipment could have been obtained and installed quickly enough to keep up with the progress of the building construction. However, by dividing the decentralized equipment order between two refrigeration machine manufacturers, it was possible to have the air conditioning ready to operate as each building was completed. Thus there was no delay in starting the production of airplanes and parts in any of the buildings, as all services, including air conditioning, were ready when the building construction was completed.

Vulnerability to Bombing

As to the vulnerability to bombing, there is but little question that the central station job is much inferior to the decentralized job. One bomb hit on the central equipment station would put the air conditioning out of commission for the entire plant. Of course, an underground location might be used, but the construction of such a machinery vault would run up an excessive cost, and to my knowledge has not been done so far for any equipment of this kind.

On the other hand, with decentralized cooling and heating equipment, a direct bomb hit on any building could affect only a few stations. The undamaged buildings could still operate at full efficiency with air conditioning unimpaired. And with all equipment practically identical, the problem of repairs and replacement to damaged equipment would not be nearly so serious as the repair or replacement of damaged central station equipment. Furthermore, the refrigerant loss would be small in case of bomb damage, whereas the central plant might conceivably lose its entire refrigerant charge from one bomb hit.

Here in California we feel that the system of decentralized air conditioning pioneered at the Douglas aircraft plant in Long Beach offers the best possible solution to the air conditioning problem for a windowless war factory in this territory. Since the Douglas plant was completed a project of comparable size, in the South, has followed this example of decentralization in order to obtain air conditioning quickly and with the least expenditure of critical materials during this war emergency.—H. M. HENDRICKSON, assistant branch engineer, York Corp.

Standardized Heating and Ventilating Equipment for Ships

THE GREAT Lakes regional office of the United States Maritime Commission gives its unqualified support to the plan of Comdr. Urdahl, Lt. Everetts, and Mr. Whittlesey for standardization of equipment. We would like to see this plan improved as suggested and extended so as to include not only the Navy, but also the Army, Maritime Commission, and all other shipbuilding—not just as a wartime measure, but as a desirable and integral part of all shipbuilding design. Steps have already been taken in the direction of such cooperation and standardization by the Washington office of the Maritime Commission.

Little can be added to the arguments set forth in their well worded and concise picture of the situation, as published in the July and August issues of HPAC. However, we would like to take this opportunity to re-emphasize some of the points mentioned, namely:

1) Elimination of oversized equipment brought about by the knowl-

edge of the actual equipment to be used.

2) The saving in spare parts (and spare parts stowage space on the ship) by the reduction in the number of sizes and types.

3) The greater ease of repair in emergencies through interchangeability.

4) The considerable saving of engineering design time and the improvement of design resulting from knowing what linear and volumetric dimensions you are working to; what the weight of the equipment is; and above all, what its capacity is. (Working in the dark in this respect seems to be a favorite time-wasting pastime of the marine industry).

5) Standardization definitely can and should result in a saving in cost, primarily because intelligent, equitable bidding would result. Under the usual situation either the manufacturer isn't sure of what is required or else a particular manufacturer is specified and the design is built around his equipment. In the latter case, the bidding is usually nothing more than a farce.

Some people may question the desirability of standardization on the basis that it promotes stagnation in the design of equipment, and consequently in design; that it will make it difficult to take advantage of good proprietary features of certain manufacturers; and that it will handicap the designer with respect to using the most economical and most efficient equipment and design because of its inherent inflexibility. As far as we are concerned the above points, if they exist at all, are far outweighed by the advantages of standardization. Many engineers and designers seem quite capable of getting in a rut or stagnating without the help of any outside inducement such as standardization, and the designs of such men would be materially helped by standards. There is no reason to believe that the committee or persons responsible for the standardization could not be alert and intelligent in reviewing the standards, keeping them up to date, and incorporating new features as they become desirable, without destroying the original features of low cost, known sizes and capacities, fewer types and sizes, and interchangeability.

Standardization for the marine industry is not new, but it has never been done extensively and on a long range basis. With respect to standardization at the present time, nothing could be truer than "It did not begin soon enough...it has not been carried far enough."—JOHN H. CLARKE and MARVIN GARDNER, heating, ventilating and refrigeration branch, engineering plan approval section, United States Maritime Commission.

IT WAS with interest that the article Standardized Heating and Ventilating Equipment for Fighting Ships written by Comdr. Thomas H. Urdahl and my friend, Lt. John Everetts, Jr., of the Navy Dept., and published in the July HPAC, was read.

A topic of this nature is of wide interest at the present time due to the great amount of heating and ventilating being designed and installed on fighting ships and ships of the merchant marine which keep the "bread line" of men, equipment, and supplies moving over the seas. Such interest is kindled by the desire to keep in rhythm with the production pace prevalent in all construction phases of the war effort, and make use of every short cut that is practical and efficient to "keep 'em flying," "keep 'em rolling" or, in this case, "keep 'em sailing."

Consequently these comments are submitted for the purpose of discussing the above article by presenting the viewpoints of an individual which in no manner shall be construed as authoritative United States Maritime Commission standards or practice.

It is peculiar to start at the end of a problem to obtain an answer but it so happens that the last paragraph of the above article is the basis for this discussion. The phrase "It (standardization) has not been carried far enough" reminds one that heating and ventilating is based on engineering fundamentals and principles from which the problem at hand is calculated and definite equipment is selected by the designer which shall produce the requirements as calculated in an efficient manner. The tendency of many designers is to not carry the engineering of ventilating systems far enough. Therefore, it is questionable whether standardization could be carried far enough to result in the inclusion of all engineering fundamentals and principles.

The key equipment in the design of a heating and ventilating system is the motor and blower. (It is intended in the word "heating" to mean hot blast supply of air to a space.) Any fluctuation in the performance of this key equipment other than what it is designed for cannot be expected to be anything but inefficient.

Experience indicates that fans were supplied to a shipyard from a pool of stock fans and that the fans as selected and delivered were capable of supplying a total cfm of air from 500 to 900 cfm lower or higher than was called for on the original design of the ventilation system. This, of course, could be overcome by ascertaining, at the time the design is made, just what cfm the selected fan will supply and then the design could be correlated thereto. This, however, may create a condi-

"Ships for Victory"

In an article on Standardized Heating and Ventilating Equipment for Fighting Ships, published in the July HPAC, Comdr. Thomas H. Urdahl and Lt. John Everetts, Jr., of the Navy Department's bureau of ships, stressed the importance of the Navy's standardization program and gave the reasons for it, showing its application to fans, preheaters and reheaters, supplementary space heaters, diffusing terminals, etc. In August, Comdr. Urdahl and W. C. Whittlesey, senior engineer, air conditioning section, shipbuilding division, bureau of ships, discussed the advantages of standardization from the designer's viewpoint, showing how standardization simplifies design and insures accuracy of the final installation.

While the problems facing designers of fighting ships and merchant ships are in many ways different, they are also in many ways similar. The editors therefore asked a number of engineers with the United States Maritime Commission to comment on the Navy's standardization program as outlined in the above-mentioned articles. These comments are published here.

The importance of both our fighting ship and merchant ship construction programs to the prosecution of the war is so obvious that it needs no stressing here. Our industry is closely concerned with this work; ventilating systems, for example, frequently outnumber other vital complementary systems on Navy ships by as much as three to one. Many vessels have as high as 300 separate ventilating systems; few have less than six.

tion whereby the required design may be disregarded and the resultant cfm would be accepted at its worth. In this view, however, it is believed that if a system is calculated, as the first step of the design, and then the fans ordered from these calculations, sufficient time is available to manufacture a fan and motor.

Let us take as an example an engine of any type. An engine is designed to operate and produce certain requirements. These requirements may be anything from pulling, pushing, or moving loads in any direction. The energy produced to perform this work is termed horsepower. Let us assume an engine was designed to produce 25 hp. The engine is designed for efficient operation under this load. It is agreed that this engine operating under loads of less or more than 25 hp is not operating to its greatest efficiency. Is this not true of a ventilation system? It most certainly is.

Simplicity of maintenance is of major importance on ships. The fewer types of equipment, the easier it is for the personnel to become familiar with the equipment. As stated in the above article, a ship may have a large number of ventilation systems. These vary from 12 to 300 systems per ship. Again experience indicates that on a ship which had fans supplied from a pool, four different types of fans and motors were furnished. It can readily be seen how such a condition complicates maintenance and adds to the quantity of spare parts required.

During wartime it is no doubt essential to have a source of supply for equipment that may be damaged in battle. Such a source could be maintained by establishing parts depots at certain locations where a complete stock of spare parts could be available at all times. There is no doubt that it is much easier to replace equipment than it is to repair it. It is a question whether it takes any longer to do one or the other. One question that is brought to mind regarding replacing material is, what happens to the old materials? Very often material is scrapped that is in good condition which could be used if a new part were replaced for a broken or worn out one that is connected with the piece that does not have to be discarded.

In conclusion, it is the writer's desire to stress the fact that it is his contention that standardization tends to eliminate the high technical standards and ethics of heating, ventilating, and air conditioning engineering which are a definite requirement for proper and efficient performance to meet the varied design requirements. — C. L. LANDFRIED, head, heating and ventilating branch, East Coast regional office, United States Maritime Commission.

THE SUBJECT of standardized heating and ventilating equipment for fighting ships is most certainly a timely one. The advantages of standardization are infinite and benefit everyone involved from the designer to the repairman.

The article in the July HPAC may be compared to the "conclusion" of an important investigation. No doubt the "object," "procedure," and other parts of the "report" would also prove interesting.

Standardization is not easy. Differences in technical opinion and manufacturing technique make the problem a difficult one. The lack of critical materials further aggravates the situation today.

The organization and purpose of the Navy and the Maritime Commission are not the same. For this reason, it is not possible for the Commission to utilize all of the standards developed by the Navy. The Navy's standards have, however, been a basis for the standardization of ventilation and heating equipment accomplished by the Commission to date.

All of us should thank the Navy for the standardization mentioned in this article, which has greatly improved the industry as a whole. —JAMES L. BATES, director, technical division, United States Maritime Commission.

OUTLINES CRITERIA USED TO DECIDE OIL CONVERSIONS

H. S. Shedlov, regional fuel rationing officer, Office of Price Administration, said in a talk before the National Association of Building Owners and Managers meeting at St. Paul in June that the deciding factor on conversion from oil to other fuels with both the Petroleum Administration for War and the OPA local rationing boards will be this: First, is it reasonable to convert? In other words, is the cost of making conversion reasonable? The criterion now used is 5c per gal for a normal year's consumption. In other words, if the facility that burns 20,000 gal. of oil a year can convert, by means of installing grates or some other equipment and can thereby burn coal, for less than $1,000, that would certainly be a reasonable conversion, and that would then be ordered. The cost figure is not an inflexible rule, but it will give some idea of whether or not from that standpoint it is reasonable to require conversion.

The second point is whether or not the materials for making the conversion are available; if it is the type of job which requires stoker installation, it would depend upon whether or not the stoker can be made available through the War Production Board.

The third criterion is: Is there an adequate supply of an alternate fuel? That is a question, of course, which is one that changes from day to day. We do know that in certain areas there is going to be an ample supply of coal available, and in those areas the PAW and OPA will push the conversion of that type of facility.

As to the availability of stoker equipment for large buildings which are anxious to convert, the WPB has allocated a sufficient amount of material so that large stoker equipment, which will replace a large quantity of oil, is going to be available.

The whole effort this year is going to be to save all the oil that we can for vital use, and we can make that saving, of course, in the shortest time and the greatest saving by requesting the conversion of those very large units which can convert at a reasonable cost.

AS MUCH—MAYBE MORE—HEATING OIL FOR EAST

The Petroleum Administration for War called upon east coast (district I) refiners last month to increase their production of home heating oil and of 80 octane, all purpose military gasoline, Petroleum Administrator Harold L. Ickes revealed. The request was contained in telegrams in which the PAW informed the refiners that August crude oil runs on the Atlantic seaboard would be limited only by the capacity of facilities.

Deputy Petroleum Administrator Ralph K. Davies said that lifting of quotas on crude oil runs in eastern refineries was possible because of the increased transportation facilities now available on the east coast. He said: "We feel confident that the east coast will get as much fuel oil as it did last year. We are hopeful that it will get more."

MEASURING the FLOW of FLUIDS

William Goodman Gives Practical Data on the Use of Orifices and Manometers

THE SIZE of the orifice to be used depends upon the maximum flow to be measured and the maximum pressure difference that can be allowed across the orifice. For the same liquid flow rate, several different size orifices can be used depending upon the magnitude of the permissible pressure difference.

Selecting Orifices for Liquids

The pressure difference that can be allowed across an orifice for a given flow depends upon the permanent pressure loss due to the orifice. Because many piping systems cannot stand the addition of extra head without decreasing the quantity of fluid flowing, and because extra power is required to pump against the pressure loss introduced by the orifice, the pressure difference across the orifice at the maximum flow is usually limited to some reasonable value.

The difference in pressure across the orifice is not the actual permanent pressure loss due to the orifice because a portion of the velocity head of the fluid flowing through the orifice is recovered. Hence, the actual permanent pressure loss is less than the pressure difference measured by the manometer. The permanent pressure loss ranges in value from about 50 to 90 per cent of the pressure difference across the orifice. The method of computing the permanent pressure loss is discussed later. For the moment it is sufficient to be aware that the pressure difference at maximum flow for which an orifice is selected is usually limited by the permanent pressure loss due to installing the orifice in the piping.

Where the permanent pressure loss is not of importance, the maximum pressure difference across the orifice is limited by the maximum length of the manometer available. Usually, for convenience, manometers are kept less than 36 in. long although longer ones can be made.

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With water flowing through an orifice, the maximum pressure difference that can be measured by a mercury manometer 36 in. long is about 16 psi. For a given flow, the greater the pressure difference across the orifice, the longer must be the manometer.

As previously stated, the size of an orifice is determined not only by the maximum flow to be measured but also by the pressure difference across the orifice at the maximum flow. For example, if the pressure difference across the orifice is to be 5 psi at the maximum flow, the orifice must be larger than if the pressure difference can be 10 psi.

For a given manometer and orifice, the smaller the flow, the shorter will be the rise of the mercury column in the manometer. But for any given flow, the rise of the mercury column will be less with a large orifice than with a small one. In other words, if a large orifice and a short manometer are used for the maximum flow, the rise of the mercury column for a lesser flow may be too small to permit the pressure difference across the orifice to be measured accurately. Hence, the orifice selected must be small enough so that at the minimum flow the pressure difference can still be measured accurately on the manometer. On the other hand, the orifice must not be so small that the permanent pressure loss will be too large. The effect of the minimum flow on the selection of the manometer length is discussed in more detail later; this preliminary discussion is given only so that some of the factors which influence the selection of orifices and manometers will be clearly understood.

The following approximate method is useful for selecting an orifice for any given maximum flow and maximum pressure difference. After an orifice has been selected by this approximate method, the maximum flow that can be measured for the given pressure difference can be calculated accurately. Usually the size selected by the approximate method will prove satisfactory. However, it may occasionally be necessary to install a slightly larger orifice in order to stay within the desired pressure difference. To select an orifice, the following formula* is used:

$$Z = \frac{W}{\sqrt{pd}} \quad \text{.....[4]}$$

After computing the value of the orifice constant Z from equation 4, the diameter of the required orifice

*See footnote on next page.

Simplifies Your Job

Situations frequently arise in industrial and engineering work where a knowledge of the quantity of fluid flowing through a pipe line is essential or desirable. In field tests an orifice permanently installed can be used to obtain much valuable information about the performance of equipment. Furthermore, orifices and manometers are invaluable for measuring flow rates in laboratory test work. Orifices and manometers are relatively simple to select and use. Given the proper data, an accurate orifice can be selected for measuring the flow of almost any fluid.

If care is used in the installation and operation of these instruments, they will give highly accurate results. Although orifices and manometers are not difficult to use, the data needed for selecting the flow coefficient for any fluid has not been available in convenient form.

The accuracy of flow measurement depends entirely upon how accurate the flow coefficient K of the orifice is known. This flow coefficient K is used in computing the quantity of fluid flowing through the orifice. Heretofore when computing the flow through a given orifice for any measured pressure difference, trial and error methods have been necessary in determining the correct flow coefficient K. With the methods presented in the article of which this is the second part, the flow coefficient K can be found directly once the pressure drop across the orifice has been measured by means of a manometer. Furthermore, in this article all of the practical data needed to properly select and use orifices and manometers are given.

Mr. Goodman is consulting engineer, the Trane Co., and a member of HPAC's board of consulting & contributing editors.

Table 1—Values of orifice constant Z

Diameter of Orifice Throat. Inches		Nominal Pipe Size — Inches								
		2	2-1/2	3	4	5	6	8	10	12
		Inside Diameter — Inches								
		2.067	2.469	3.068	4.026	5.047	6.065	8.071	10.192	12.090
5/8	0.625	7.4								
3/4	.750	10.7	10.7							
7/8	.875	14.7	14.6							
1	1.000	19.6	19.2	19.0						
1-1/8	1.125	25.2	24.6	24.1						
1-1/4	1.250	32.1	30.8	30.0	29.6					
1-3/8	1.375	40.5	37.9	36.6	36.0					
1-1/2	1.500		46.4	44.1	43.0					
1-5/8	1.625		56.2	52.4	50.7	50.1				
1-3/4	1.750			61.8	59.1	58.3				
1-7/8	1.875			72.6	68.4	67.1	66.6			
2	2.000			84.9	78.5	76.6	76.0			
2-1/8	2.125			98.6	89.6	86.9	85.9			
2-1/4	2.250				102.0	98.0	96.6			
2-3/8	2.375				115.0	110.0	108.0			
2-1/2	2.500				130	123	120	118		
2-5/8	2.625				146	136	133	131		
2-3/4	2.750				163	151	147	144		
2-7/8	2.875					167	161	157		
3	3.000					184	177	172		
3-1/4	3.250					223	210	203	200	
3-1/2	3.500					268	248	236	233	
3-3/4	3.750						292	274	268	267
4	4.000						341	314	306	304
4-1/4	4.250							358	347	344
4-1/2	4.500							406	392	387
4-3/4	4.750							460	439	432
5	5.000							519	490	481
5-1/2	5.500							655	602	587
6	6.000								734	706
6-1/2	6.500								888	841
7	7.000								1065	993
7-1/2	7.500									1168
8	8.000									1367
8-1/2	8.500									1591

for any given pipe size can be selected from Table 1. The following example illustrates the method of using equation 4 to select an orifice.

Example 3: An orifice is to be installed in a 4 in. standard weight pipe through which calcium chloride brine is flowing. The maximum flow to be measured by the orifice is 300 gpm. The maximum pressure difference across the orifice is not to exceed 6.7 psi. The specific gravity of the brine is 1.2 and its viscosity is 6 centipoises. Calculate the orifice diameter required.

Solution: Density of brine $= 1.2 \times 62.3 = 74.8$ lb.

Using the following form of equation 3 [see p. 416, August HPAC],

$$W = \frac{d \times \text{gpm}}{7.48}$$

$$= \frac{74.8 \times 300}{7.48}$$

$$= 3000 \text{ lb per min}$$

Using equation 4,

$$Z = \frac{3000}{\sqrt{6.7 \times 74.8}}$$

$$= 134$$

Referring to Table 1, for $Z = 134$ and a 4 in. pipe, an orifice diameter of 2½ in. is required.

After selecting the orifice size by the approximate method illustrated in the preceding example, the orifice size may be checked by means of equations 1 and 2 [pp. 413 and 415, August HPAC] to be sure that the given maximum pressure difference will not be exceeded when the maximum quantity is flowing. The following example illustrates the method of making a final check on the selected orifice.

Example 4: Take the conditions of example 3 and determine whether the 2½ in. orifice will measure the desired quantity with the limiting pressure difference of 6.7 psi if flange taps are used.

Solution:

$$R_w = 11{,}940 \times \frac{2.5}{6} \sqrt{6.7 \times 74.8}$$

$$= 111{,}400$$

Also, from Table 1, inside diameter of 4 in. pipe = 4.026. Hence,

$$\frac{D}{D_1} = \frac{2.5}{4.026} = 0.621$$

Referring to chart C, p. 413, August HPAC, which is for 4 in. pipe with flange taps, for $D/D_1 = 0.621$ and $R_w = 111{,}400$, the value of K is 0.667.

Using equation 1,

$$W = 31.5 \times 0.667 \times (2.5)^2 \sqrt{6.7 \times 74.8}$$

$$= 2940 \text{ lb per min}$$

Using equation 3,

$$\text{Gpm} = 7.48 \times \frac{2940}{74.8}$$

$$= 294$$

The quantity of 294 gpm is close enough to the required 300 gpm so that a 2½ in. orifice will be satisfactory. It is well to be aware, however, that—neglecting a small change in the value of K—the pressure difference increases as the square of the quantity measured. Hence, for 300 gpm flowing through a 2½ in. orifice instead of 294 gpm, the pressure difference will be nearly 7 psi instead of 6.7 psi. By the methods to be discussed later, it can be shown that the rise of the mercury column in the manometer will be 15 in. for a pressure difference of 6.7 psi; and 15.7 in.

Symbols

D = throat diameter of orifice in plate, in.;
D_1 = inside diameter of pipe in which orifice is installed, in.;
d = density of fluid at pressure P *ahead* of orifice, lb per cu ft;
K = flow coefficient of orifice;
p = pressure difference across orifice, psi;
R_p = Reynolds number, $\frac{4}{\pi} \frac{W}{Du}$;
R_w = modified Reynolds number for selecting flow coefficients;
u = viscosity of fluid flowing through orifice, centipoises;
W = weight of fluid flowing through orifice, lb per min;
Z = orifice constant.

*Equation 1 on p. 413 of the August HPAC may be written

$$31.5\ KD^2 = \frac{W}{\sqrt{pd}} \quad \text{.....[a]}$$

Let

$$Z = 31.5\ KD^2 \quad \text{.....[b]}$$

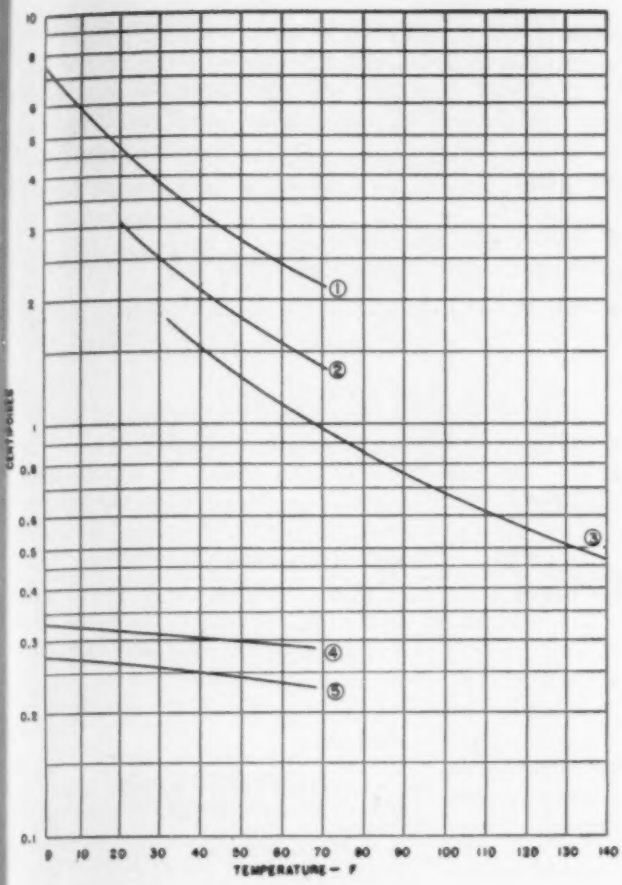
Hence,

$$Z = \frac{W}{\sqrt{pd}} \quad \text{.....[c]}$$

This is equation 4 of the text.

Values of Z in Table 1 were computed from equation b above. Values of K for flange taps at $R_p = 200{,}000$ were used. For the purposes of Table 1, these values are accurate enough even for radius and vena contracta taps.

Regardless of the pipe size, the values of K are nearly the same for given values of the ratio D/D_1. Accordingly a curve was prepared for the average values of K versus the ratio D/D_1. The values of K required in equation b above were read from this curve.



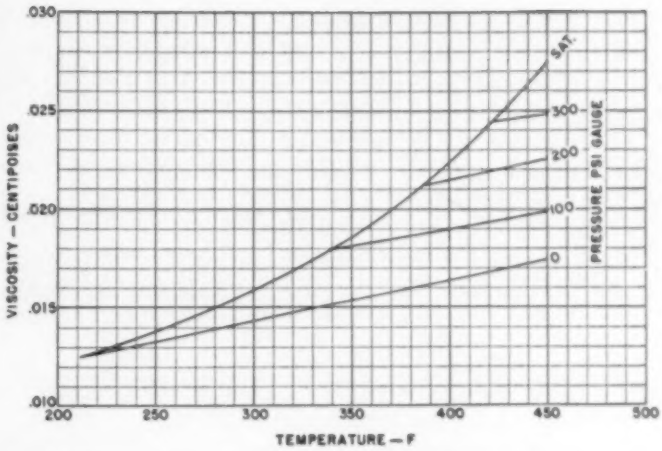


Fig. 2—Viscosity of saturated and superheated steam. (Above 300 F, interpolated from curves in Flow Measurement—1940; below 300 F, from Speyerer)

Fig. 1—Viscosities of a few liquids

Curve No.	Substance	Source of Data
1	Calcium chloride 1.2 specific gravity	Gould & Levy, Univ. of Ill. Bulletin No. 182
2	Calcium chloride 1.1 specific gravity	Gould & Levy, Univ. of Ill. Bulletin No. 182
3	Water	Int. Critical Tables
4	Methyl chloride, 99.6 lb abs press.	Refrig. Data Book, 1937-38
5	Ammonia, 171 lb abs press.	Refrig. Data Book, 1937-38

for a pressure difference of 7 psi for the conditions of example 3. Inasmuch as a manometer at least 18 in. long should be used to measure a mercury height of 15 in., a 2½ in. orifice will be satisfactory for the conditions of example 3.

The preceding two examples illustrate the necessity of checking the orifice selected by means of equations 1 and 2. Although the use of Table 1 will save time in selecting an orifice, an orifice selected by means of this table should always be checked as in example 4.

Where the value of Z computed by means of equation 4 is greater than the largest value shown in Table 1 for the given pipe size, either a larger pressure difference must be used or the orifice must be installed in a larger size pipe. In the latter case, the larger pipe need be used for only a short length before and after the orifice. The minimum length of larger pipe required before and after the orifice can be found in Tables 11 to 16, to be published later.

The values in Table 1 were computed by using values of K which were all selected at a Reynolds number of R_p=200,000. For higher values of Reynolds number, the

Viscosity of Hot Water

Temp. F	Viscosity, Centipoises	Temp. F	Viscosity, Centipoises
160	0.401	280	0.205
180	0.348	300	0.190
200	0.305	320	0.177
220	0.271	340	0.165
240	0.245	360	0.155
260	0.223	380	0.146

Viscosity data below 200 F from International Critical Tables; above 200 F from The Viscosity of Water and Superheated Steam, ASME FSP-57-11, Hawkins, Solberg, and Potter.

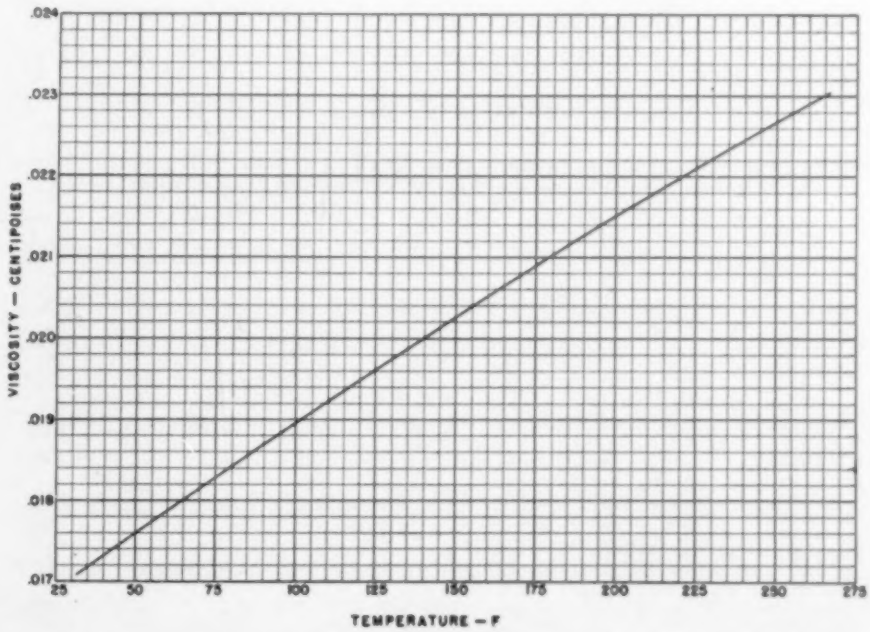


Fig. 3—Viscosity of air. (Data from International Critical Tables)

pressure difference across orifices selected by means of Table 1 will be slightly larger than the pressure difference for which the orifice was selected. For values of Reynolds number less than 200,000, the pressure difference will be lower than the pressure difference for which the orifice was selected. It is for this reason that the orifice size selected by means of Table 1 should be checked as in example 4. The use of Table 1 does, however, save considerable trial and error arithmetic for those who select orifices only occasionally.

Viscosities of Fluids

For convenience, the viscosities of a few liquids are shown in Fig. 1; the viscosity of steam, both saturated and superheated, in Fig. 2; and the viscosity of air in Fig. 3. In Fig. 1 the viscosity of water is shown only to 140 F. Inasmuch as the viscosity of water at higher temperatures may be needed, these data are given in the accompanying table.

Answering the Question:

How Much of My Fuel Should I Have Used?

TWO TABLES were published in the August HPAC, the first showing for various localities in the United States the fuel burned in each month as a percentage of the total fuel burned during a heating season of a normal number of degree days, and the second showing the total fuel burned from October 1 to the end of any month as a percentage of the total fuel burned during a heating season of a normal number of degree days. The degree day data on which these tables were based were taken from the ASHVE's Heating, Ventilating, Air Conditioning Guide 1943.

There is published this month two similar tables covering various Canadian localities. These are used in exactly the same way as are the U. S. tables which appeared in August.

Table 1—Percentage of total fuel burned in each month for a year of normal degree days

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
ALTA												
Calgary	7.5	11.8	14.0	16.9	14.4	12.5	7.6	5.0	2.7	1.2	1.9	4.5
Edmonton	6.9	12.0	14.8	17.8	14.7	12.6	7.0	4.2	2.6	1.2	1.8	4.4
BRITISH COLUMBIA												
Vancouver	8.6	11.5	14.5	15.6	13.2	12.4	8.9	5.9	3.1	1.1	0.5	4.7
MANITOBA												
Winnipeg	6.7	11.8	16.4	19.2	16.4	14.2	7.3	4.2	0.8	...	0.6	2.4
NEW BRUNSWICK												
Moncton	7.0	10.4	15.0	17.1	16.1	13.3	9.1	5.2	2.4	...	1.0	3.4
NOVA SCOTIA												
Halifax	6.5	10.1	14.9	17.0	15.3	14.1	10.2	6.5	2.7	...	...	2.7
ONTARIO												
Ottawa	6.8	11.4	16.8	19.3	17.1	14.6	8.0	3.2	0.4	...	...	2.4
Port Arthur	6.8	10.9	14.8	17.4	15.5	13.6	8.6	5.3	2.3	0.6	0.8	3.4
Toronto	7.2	11.3	15.7	17.3	15.6	15.7	9.3	4.8	0.8	...	...	2.3
PRINCE EDWARD IS.												
Charlottetown	6.7	10.3	14.8	14.0	13.4	14.4	10.4	6.3	2.5	...	...	7.2
QUEBEC												
Montreal	6.7	11.5	16.7	19.0	17.1	14.5	8.6	3.7	...	...	...	2.2
Quebec	6.9	11.1	16.0	18.0	15.7	14.1	9.2	4.6	1.3	...	0.3	2.8
SASKATCHEWAN												
Saskatoon	7.0	11.2	15.1	18.4	15.9	13.8	7.0	4.0	1.8	0.5	1.4	3.9

Table 2—Accumulated percentages from October 1 to end of month. These accumulated percentages show total fuel burned from October 1 to end of any month for a year of normal degree days

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
ALTA												
Calgary	7.5	19.3	33.3	50.2	64.6	77.1	84.7	89.7	92.4	93.6	95.5	100.0
Edmonton	6.9	18.9	33.7	51.5	66.2	78.8	85.8	90.0	92.6	93.8	95.6	100.0
BRITISH COLUMBIA												
Vancouver	8.6	20.1	34.6	50.2	63.4	75.8	84.7	90.6	93.7	94.8	95.3	100.0
MANITOBA												
Winnipeg	6.7	18.5	34.9	54.1	70.5	84.7	92.0	96.2	97.0	...	97.6	100.0
NEW BRUNSWICK												
Moncton	7.0	17.4	32.4	49.5	65.6	78.9	88.0	93.2	95.6	...	96.6	100.0
NOVA SCOTIA												
Halifax	6.5	16.6	31.5	48.5	63.8	77.9	88.1	94.6	97.3	...	...	100.0
ONTARIO												
Ottawa	6.8	18.2	35.0	54.3	71.4	86.0	94.0	97.2	97.6	...	...	100.0
Port Arthur	6.8	17.7	32.5	49.9	65.4	79.0	87.6	92.9	95.2	95.8	96.6	100.0
Toronto	7.2	18.5	34.2	51.5	67.1	82.8	92.1	96.9	97.7	...	...	100.0
PRINCE EDWARD IS.												
Charlottetown	6.7	17.0	31.8	45.8	59.2	73.6	84.0	90.3	92.8	...	...	100.0
QUEBEC												
Montreal	6.7	18.2	34.9	53.9	71.0	85.5	94.1	97.8	...	...	...	100.0
Quebec	6.9	18.0	34.0	52.0	67.7	81.8	91.0	95.6	96.9	...	97.2	100.0
SASKATCHEWAN												
Saskatoon	7.0	18.2	33.3	51.7	67.6	81.4	88.4	92.4	94.2	94.7	96.1	100.0

STOKER SALES DOUBLE

Factory sales of class A stokers, ranging in size from 61 to 1201 lb per hr of coal, more than doubled in the first six months of this year compared with the same period in 1942, according to statistics released by the U. S. Bureau of the Census, the Committee of Ten—Coal & Heating Industries, Inc., reports. Sales in the first six months of 1943 totaled 11,251 units, with 5401 in 1942 and 4573 in 1941.

The large majority of class A installations and sales this year have converted oil burning plants to coal, with most of these conversions made in the eastern states.

Class 5 (over 1200 lb per hr) or power size stoker sales show a slight increase this year as compared to 1942 and 1941, with 839 units for the January-June months in 1943, 826 in 1942, and 591 in 1941. Factory sales of residential size stokers (class B) in 1943 have been negligible owing to the fact that the manufacture of such units was discontinued September 30, 1942, by order of the War Production Board.

18,500 WORKERS KILLED ON THE JOB

Accidents—97 per cent of them preventable—cost the nation $5,200,000,000 and 380,000,000 man-days of work in 1942, the National Safety Council reveals in the 1943 edition of its annual statistical yearbook, Accident Facts.

On the job accidents killed 18,500 workers—500 more than in 1941—injured 1,750,000 (150,000 more than in 1941) and resulted in a loss of time sufficient to have built 18,000 heavy bombers or 55 battleships.

SAM LEWIS' PAGE

By Samuel R. Lewis
Consulting Mechanical Engineer
Member of HPAC's Board
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High Temperature of Condensate Causes Trouble in Factory Heating

• *On this page, Mr. Lewis comments informally on a few of the problems he has met and is meeting in his wide and varied experience as a consulting engineer doing heating, piping, and air conditioning work. Some of the time you will agree with him . . . some of the time you won't . . . but you'll always find him interesting and thought-provoking. His "page" runs longer than usual this month; he answers a question about the heating of a manufacturing plant, asked by a reader of HPAC. His practical suggestions for remedying the difficulty apply to many existing installations.*

A correspondent has submitted an interesting question concerning a heating system in a manufacturing plant. The boilers are operated at from 75 to 100 psi steam pressure and the buildings are heated by unit heaters fitted with electric fans. The convectors in the unit heaters and the ends of the steam supply mains have high pressure float traps. The condensate is returned to steam driven vacuum pumps in the boiler room which discharge it to a receiver, from which other steam driven pumps force it back into the boilers.

Complaint is made that the condensate returns to the vacuum pumps at a temperature so high that it flashes into steam due to pressure reduction at the vacuum pump suction. In consequence it is the custom to inject cold water continuously at the suction strainers.

Since the plant is employed exclusively for heating, with no loss of steam to the atmosphere, it becomes necessary continually to blow down the boilers, thereby wasting much clean, hot water to the sewer. This is a decidedly uneconomical procedure, involving serious costs for fuel and for water, to say nothing of the objectionable scale continually being deposited on the heat absorbing interior surfaces of the boilers.

The correspondent, who is a heating contractor independent of the factory management, has suggested the following:

1) That the bucket traps may be passing steam into the return mains and that these traps should be made tight.

2) That outlying flash tanks might be installed to permit the hot water to vaporize so that the vapor may condense by transmitting heat to the surrounding air.

3) That heat exchangers might be installed in the return mains cooled by water in a closed system, the hot water then being conserved for some industrial purpose.

4) That automatic water level governors be connected to the boilers, stopping and starting the boilerfeed pumps via pressure-actuated pump governors on the steam supply pipes to the pumps.

5) That the steam pressure on the heating system might be reduced through automatic pressure reducing valves.

It is reported that the operating engineer does not like low pressure heating and that he believes that the buildings cannot be kept warm with less pressure than 75 to 100 psi in the convectors of the unit heaters.

It is not clear from the data given whether the steam mains and connections to the unit heater convectors are large enough to supply them with steam at, say, 5 psi pressure.

Suggestions for Correcting the Trouble

Considering the contractor's suggestions in the order stated above, solution (1) will not end the trouble, since any bucket trap can distinguish only between steam and water at the pressure and temperature condition existing in the trap. Water at 75 psi pressure will be at a temperature of over 320 F. If the pressure is reduced, as it must be in passing through the orifice at the trap and expanding in the return mains, a large percentage of the water flashes into steam and there is not enough heat losing surface in the relatively small return pipes to permit the change of state from vapor back to water—which involves removing more than 100 Btu per lb of water, in addition to 966 Btu latent heat per lb of steam.

The reciprocating vacuum pumps can handle a mixture of hot water and air at somewhere near 212 F, but cannot be expected to handle an elastic, constantly flashing mixture of water and steam at a temperature far warmer than the boiling point of water at the encountered pressure.

Solution (2) will require relatively enormous flash tanks, since the condensate cannot stabilize as liquid unless the superheat of the liquid is removed. Flash tanks are successful for relatively small volumes of superheated condensate provided that each one has a relief connection or vent into a low pressure heating system, as well as a trapped drain into a low pressure water return.

There is no provision in this plant for condensing the vapor which would have to be removed from flash tanks.

Solution (3) installing condensing surfaces fed by the return mains and in which part of the superheated water could expand into steam while cooled and stabilized water at somewhere near atmospheric pressure could go to the vacuum pumps, would solve part of the trouble, but we have no evidence that there is use for the considerable volume of hot water which would thus be available.

Solution (4) would reduce the engineer's labor in watching the boiler water level and manipulating the blowoff valves, and is a very desirable arrangement for any high pressure boiler plant. But this scheme would not prevent overflowing the receiving tank and wasting clean, hot water to the sewer, as long as jet cooling water continues

to be introduced at the suction strainers of the vacuum pumps.

Reduce Steam Pressure on Heating System

Solution (5) approaches a reasonable correction in an intelligent manner.

If the mistakes in operation are not corrected quickly, the owner will face very serious maintenance expense, as well as continuing to face the inexcusable cost for fuel.

There is an almost exact case in point in a similar large manufacturing plant in another locality, where the unit heaters operated at only 50 psi pressure. The traps were of the float type. The condensate drained to the receiver of two electric pumps which forced the condensate to the boilers.

In this case, solution (1) proved ineffective even though all of the traps were replaced several times. The outstanding eventual difficulty was that the steam and return piping commenced to fail. The entire piping system eventually was torn out and replaced, because at the 50 psi pressure it was impossible to get rid of the air originally inside the system, plus the air constantly entering with the steam. Excess air in combination with moisture and heat is a terrifically corrosive agent. The steam driven vacuum pumps in the plant which our correspondent asks about doubtless do extract much of this excess air, but float traps are poor air vents and there are no automatic air vents on the convectors and mains which will function at a temperature of around 300 F. The return pipes, the vacuum pumps, and the receiver eventually will show serious corrosion.

We find very few steam heating systems which have steam piping so small that relatively low pressure steam cannot be forced through them in adequate quantities. We find almost no unit heater installations which have convectors so small that steam at, say, 5 psi entering, with atmospheric pressure on the return piping, will fail to give satisfaction.

If the existing unit heaters will not heat the buildings at low pressure, the addition of a very small number of extra heaters will compensate.

If the steam piping is too small to deliver enough steam to the convectors all the way from the boiler room at low pressure, it is possible (at relatively low cost) to install several outlying reducing valves, the high pressure mains supplying them, with comparatively short, new, low pressure mains near the revised centers of distribution.

It is evident that this case is one in which a comprehensive analysis of the piping and venting and drainage is indicated, and one in which the operating engineer needs friendly cooperation.

There is too much background of experience with low pressure steam heating versus high pressure steam heating, and too much unnecessary loss to the owner in fuel and in risk of very heavy investment for replacement when high pressure heating is used, for me to advise anything short of serious consideration of solution (5), probably adding solution (4) and new thermostatic traps. The water injector pipe ought to be disconnected and thrown away.

Governmental agencies at present are requiring that the design of unit heater systems in large factories shall be based on 50 psi, in order to reduce pipe and convector metal. These agencies and myself do not see the matter eye to eye.

USERS OF LESS THAN 10,000 GAL OF OIL NOT REQUIRED TO CONVERT

Heating oil rations will be granted to consumers using less than 10,000 gal regardless of whether their equipment can be altered to the use of coal, the Office of Price Administration announced August 23 with the issuance of amendment 76.

Mainly affected by this major revision in conversion policy are hotels, apartment houses, office buildings, and similar consumers, defined as "other than private dwellings," in New York, Pennsylvania, New Jersey, Delaware, Maryland, West Virginia, Virginia, North Carolina, South Carolina, Ohio, Kentucky, Indiana, Illinois, Michigan, Wisconsin, Iowa, Minnesota, and the District of Columbia. These users will receive oil allotments for 1943-44 without regard to convertibility if their basic ration last year amounted to less than 10,000 gal. Users who have already converted will not be eligible for a new oil ration.

Last May 10, the OPA announced the removal of all "convertibility tests" for obtaining auxiliary or supplementary rations for private dwellings in the 33 eastern, middle western, and Pacific northwest states under oil rationing. At that time OPA also stated that conversion would not be required for buildings other than private dwellings, which received a 1942-43 heating ration of less than 10,000 gal, located in the New England states and in North Dakota, South Dakota, Kansas, Nebraska, and Missouri. In Georgia and Florida (east of the Apalachicola River) and the Pacific northwest, conversion is not required of any heating oil consumer, irrespective of the size of the ration.

RECENT AMENDMENTS TO FUEL OIL RATIONING ORDER

An index to amendments Nos. 1 to 50 to the fuel oil rationing order appeared on pp. 171-172 of the April HPAC. Amendments 51-60 were covered on p. 233 of the May HPAC, amendments 61-65 on p. 52, front section, June HPAC, and amendments 66-71 on pp. 411-412 of the August HPAC. The following information on amendments 72-73 has been taken from OPA fuel oil industry letters issued last month:

Amendment 72, effective on July 19, 1943, provided that fuel oil inventory coupons, issuance of which was stopped July 1, were to be withdrawn from use by August 31, and beginning August 16 no fuel oil may be transferred in exchange for inventory coupons now outstanding. Dealers and others who had any of these coupons on hand on August 16, should have, no later than August 31, deposited them in their ration banking accounts if they are depositors, or exchanged them at local boards for exchange certificates if they do not come under ration banking. The amendment also authorizes the elimination of the "certificate of removal or transfer and surrender of coupon sheet" from the new coupon sheets for next season's rations. The use of the certificate will in the future be required only upon the surrender for class 1 or class 2 coupon sheets which were issued for use during the 1942-43 heating year.

Amendment 73, effective July 24, changes the language but not the substance of the provision in ration order 11 with reference to the use of boats for fishing purposes, to make the language parallel the same provision in the gasoline regulations—ration order 5C. It also corrects two inadvertent omissions of phrases from previous amendments.

One man alone can handle a 20 ft section of the light weight flexible pipe used in the portable petroleum pipe line, which helped make possible the allied North African blitz. Sydney S. Smith, who conceived and designed the portable line, looks on approvingly as a section is carried into position.

PORTABLE PIPE LINE HELPS WIN THE WAR

Can Be Laid at Rate of Ten to Thirty Miles per Day by Unskilled Personnel—Used in North African Campaign for Transporting Gasoline and Water in Separate Lines

WHEN WORLD War II broke out, Sydney S. Smith, manager of the products pipe line department for the Shell Oil Co., Inc., began thinking in terms of the petroleum transportation difficulties which an army would face in conducting a "blitz" war. The sheer weight of petroleum products in bulk represented one appalling problem and the exposure of oil carrying trucks to air attack was another.

In his spare moments, more as a patriotic contribution than anything else, Mr. Smith put on paper a design for a portable pipe line in the belief that it might some day be of use to the United States. When the plan was completed, he showed it to Norman J. McGaw, vice president in charge of transportation and supplies for Shell, who authorized an appropriation of $10,000 for portable pipe line experimentation in the middlewest.

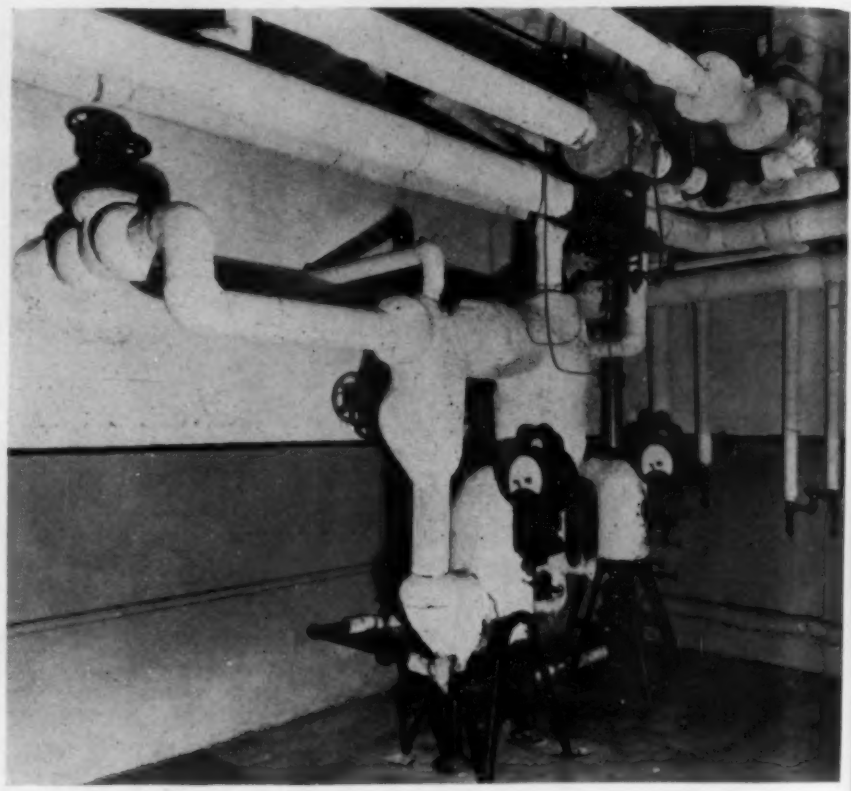
The plan had been completed but no tests had been made when in 1941 Mr. McGaw was visited by a Mr. Bansfield, who made inquiries about the possibility of oil transportation over the Burma road. He and Mr. McGaw discussed the hazards of bombing as well as poor surfacing, etc., which the Burma road presented. Mr. McGaw said that a pipe line was the answer and called in Mr. Smith. The Smith plan was discussed in some detail and the matter was taken up with Alexander Fraser, president of Shell.

Mr. Fraser asked Mr. Smith for a complete report on the proposed portable pipe line. In five days a 33 p. report, illustrated by 18 prints, was prepared and submitted to the Shell president. Some of the features of the plan: 20 ft sections of flexible pipe were to be used; pumping stations could be located at 20 mile intervals; all of the equipment —pipes, couplings, pumps, etc.— could be transported on trucks, in

[*Concluded on p.* 470]

Converting from Oil to District Steam

L. W. Mauger Describes Program of a Large Real Estate Management Firm



IN THE spring of '42, when the outlook for unlimited supplies of fuel oil became dark, studies were made of all our buildings situated in the sections of Manhattan served by the New York Steam Corp. so that we would be prepared to swing these properties to district steam in the event that this service seemed to be the most desirable alternate. Some of these properties had been served by the steam company at some time in the past and oil burning boilers had been installed in order to reduce the operating costs by taking advantage of the relatively low prices of No. 6 fuel oil. Others had no connections from the steam mains to the buildings and for these, it was necessary to excavate the streets and install new connections.

In making conversions to district steam, the prime consideration was uninterrupted service for tenants. Possible use of coal, either hand or stoker fired, was usually considered and, in some buildings, the operating expense would have been less than the cost of district steam service, but many oil burning properties were not laid out with conversion to coal in mind. The space in front of the boilers in some cases was insufficient and there were no facilities for the storage of coal or for the removal of ashes. For many properties, the additional labor needed for handling coal and ashes presented a difficult problem both from the standpoint of expense and obtaining the required personnel. After considering all items of expense involved, the cost of central station steam service was found lower than coal for many of the properties studied.

For buildings whose peak loads on cold mornings exceed 4000 lb per hr of steam, the district steam rate schedule provides that the boilers may be leased to the company for operation on designated days in extreme weather to supply steam for the building. There were two forms of leases, one of which provided that the operating labor shall be supplied by the owner and the other of which stated that the operating labor shall be provided by the steam company, but most of the leases for oil burning buildings have been made under the first of these plans. The operation of leased boilers relieves the extreme loads on the central stations and on the distributing mains and has made it unnecessary for these facilities to be increased in capacity in order to supply the large number of buildings that have been converted from oil to steam. The rental received for the boilers in effect reduces the heating expense for these properties.

Wartime Problems

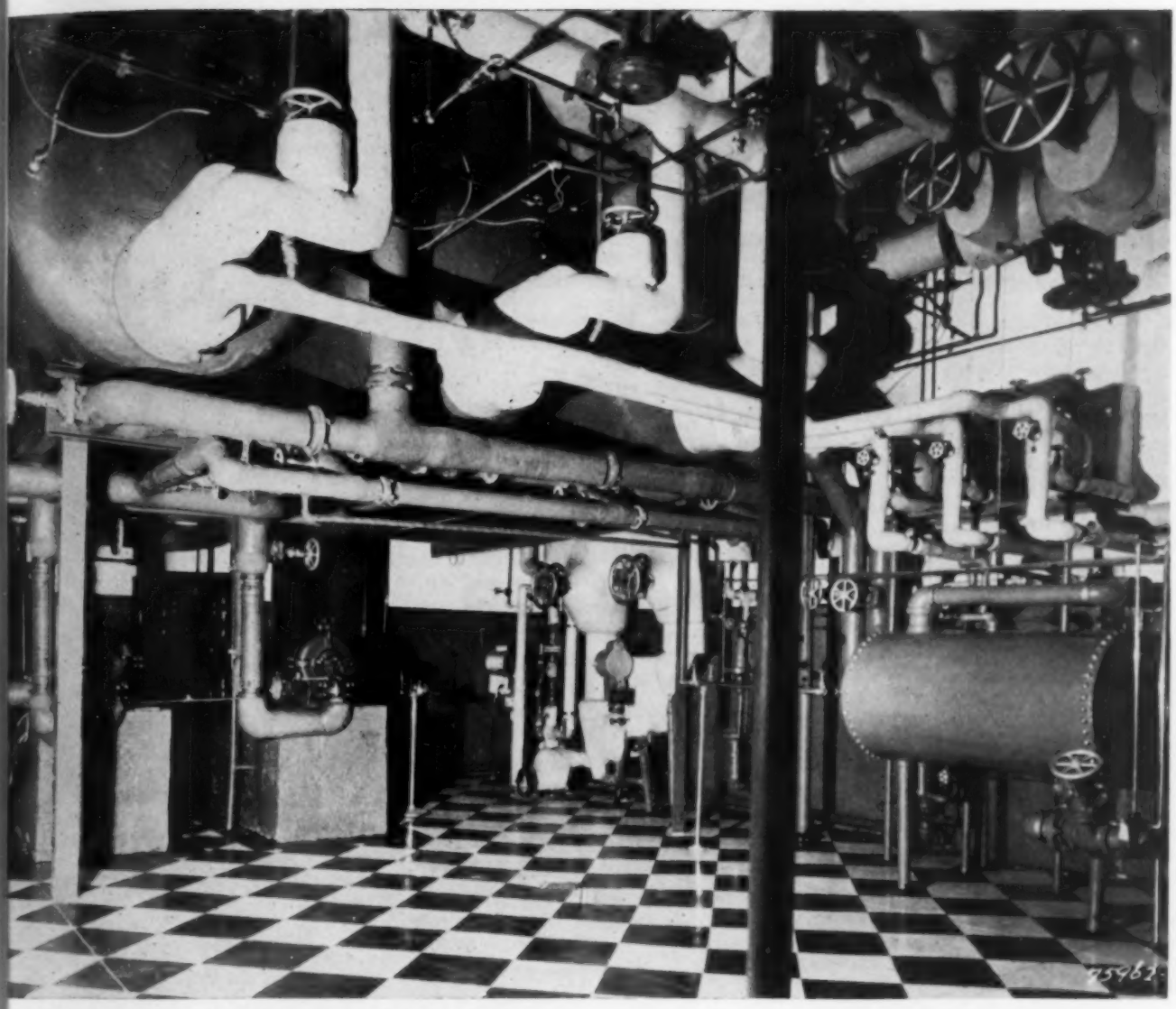
In sections served by district or central station steam, many buildings have solved the problems posed by fuel oil restrictions by converting to street steam. Mr. Mauger — supervising engineer of the New York real estate management firm of Brown, Wheelock, Harris, Stevens, Inc. — discusses the program of conversion inaugurated in the spring of 1942 for one group of properties.

His discussion is of particular value to those now considering the use of district steam for the coming heating year. Among the topics covered are the connections from mains to buildings under wartime restrictions, providing for the heating of domestic hot water, and the relation between previous fuel oil consumption and estimated street steam requirements.

Connections from Mains to Buildings

The connections from district steam to the building mains have taken anywhere from eight days to eight months, with the average probably eight weeks. In the first category would be those buildings in which the mains were already installed and only a short connection, or perhaps a metering combination, had to be added. For some of the small buildings in which lines could be run from adjoining properties, the installations have been relatively quickly completed. For most of the properties, there was a considerable delay in obtaining the original preference ratings and in order to facilitate granting of priorities, piping layouts were redesigned to reduce the amount of material involved by cutting some of the standard connection arrangements. For example, bypasses were usually eliminated from meter combinations, and standard pipe and screw fittings were used for small sizes rather than extra heavy pipe and flanged fittings.

In making connections to steam mains, it was often necessary to install king valves in the boiler outlets. Since most heating jobs operate on low pressure and steam is distributed throughout the city at 125 psi pressure or more, reducing valves are required for practically all jobs. In most cases, two valves are used for the sake of safety and accurate con-



Typical district steam installations in buildings, showing the piping, the pressure reducing valves, the meters, etc.

trol, and delivery of reducing valves was a bottleneck.

Ordinarily, it is considered good practice to install some form of steam regulating device which may be operated by a thermostat or time clock and, in the case of steam installations, these have been usually connected to one of the reducing valves, either through a pilot mechanism or half circle motor, to open and close the valve. The returns from the heating system must be below 100 F before they are run into the house sewer and it has been the practice to cool these returns either by passing them through a cooling coil or a preheater in which some of the heat may be used for generating hot water. Preheaters have been difficult to obtain, so that the economy that might thus be produced has been lost.

One distinct advantage of converting to district steam was the fact that the installation costs would be borne by the steam company provided they were not in excess of one year's estimated steam bills. If the cost of the connections was estimated at less than 40 per cent of the annual revenue, the installation would be made without expense to the owner, provided a contract was signed for one year. If the estimated cost was between 40 and 70 per cent, a two year contract was required; if between 70 and 90 per cent of the annual revenue, a three year contract was necessary; and if it was between 90 and 100 per cent, a four year contract was requested. The expense of connections included service lines, valves, fittings, meter combinations, connections, and returns. It did not include changes in the building equipment or the installation of special items needed for unusual conditions. However, these items ordinarily would represent only a small percentage of the total cost, so that the owners were able to avoid any large capital expense for conversion.

Furthermore, the conversion to district steam usually did not involve any change in the boilers or fireboxes and the oil burners could be left intact to be used in case of emergency. The burners would then be ready to be restored to operation, if fuel oil should again become available at a reasonable price, without any expense for reconverting to oil.

Providing for Heating Hot Water

In many of the buildings with oil burning boilers, hot water was supplied by means of instantaneous submerged coils installed in one or more boilers. This presented a problem in introducing steam since the standard method of generating hot water with steam is by means of steam coils in storage tanks. Storage tanks were difficult to obtain, but their installation would have been expensive even if they were available, so that in most cases new tanks were not purchased.

For some properties, hot water requirements could be taken care of by means of instantaneous heaters in which there was a direct transfer of heat from the steam to the water in a drum equipped with coils. This method is satisfactory for some types

of buildings, but it requires large coils and high rates of steam flow. If the hot water load was normal, it was sometimes generated by opening the boiler king valves so that steam would be fed into the top of the boiler drum and condensed on the surface of the boiler water. One difficulty with this system was the tendency for a layer of air to accumulate above the boiler water, so that the steam did not come in contact with the full area and therefore, the rate of condensation was too slow to keep the boiler water heated. This has been overcome by installing vents just above the water level to release this pocket of air.

It was also necessary to arrange for draining excess water from the boiler as the steam condenses; this should be released from the bottom of the boiler where the water is coldest. With the boiler water heated to 180 F or more, the submerged coils would continue to supply hot water to the building as they did when the oil burners were in operation. One distinct advantage of this system was that it did not involve any extensive change in the boiler and, it was relatively inexpensive. No control device was necessary, other than a pressure regulator, since the temperature of the boiler water would never exceed that of the low pressure steam.

Another method of heating the boiler water was developed by installing steam coils in the boiler drums, below the submerged hot water coils if possible. The steam coils heat the boiler water and this in turn heats the water in the submerged coils for domestic purposes. This system appears to have a greater capacity than the system of supplying steam to the surface of the water, but it does require an expense for coil installation and in some cases, means that boiler tubes must be removed in order that the new steam coils may be accommodated. It also requires a steam control device regulated by the temperature of the boiler water to prevent heat from the steam in the coils, which might be at from 5 to 10 psi pressure, from generating steam in the boiler. In some instances, when there was a delay in the delivery of temperature regulators, it was necessary to open the king valves to relieve this pressure of steam. During the winter, this made practically no difference because this steam was then utilized in heating the building, but during the summer, it would be difficult to dispose of this excess steam.

Relation of Oil to Steam Consumption

In all of these conversions, estimates were prepared based upon previous experience with purchased steam or upon the consumption of fuel oil. There has been considerable variance in the relation between the quantity of fuel oil used and the amount of steam consumed, depending upon the efficiency of the boiler and burner operation and the method of regulating the steam. In cases where a temperature regulator had been used for an oil burner and the same regulator was adapted for use with steam, a direct comparison between oil and steam was possible. It has been found that an equivalent of between 80 and 90 lb of purchased steam are required per gallon of oil previously used for low pressure heating. For buildings in which there were no control devices for oil, and an effort is made to use steam in a conservative manner, this factor is sometimes as low as 70 lb.

For steam power plants in which the rate of evaporation may run from 100 to 120, unless there are steam auxiliaries which may be shut down when steam is purchased, the equivalent steam should run about the same as shown by flow meters. If the meters show the amount of feedwater, blowdown must be deducted. For one of the hotel power plants the cost of purchased steam based upon meter readings would have been considerably higher than the cost of operating the plant. The steam company estimated the cost disregarding the flow meters and using an evaporation of less than 100 lb of steam per gal of oil. This plant has just been converted to steam to assure continued operation and the results will show which calculation was correct.

[*Concluded from p.* 467]

trailers, or on mule back; no trenches needed to be dug since the flexible pipe could follow the contours of the countryside; the flow could be stopped automatically at any point along the line; automatic pressure controls would prevent trouble in case of a break.

The plan was accepted by Chinese interests, and application was made for the required steel under lend-lease. Much of the pipe had been accumulated for transportation when U. S. Army authorities, studying the plan, reached a quick decision that it could become an important cog in plans for United States operations abroad. The 1000 miles of pipe ordered for China was diverted to North Africa instead because in the meantime the Burma road had been lost.

Tests were made by the Army in the Shenandoah valley. During the tests a flood washed out a bridge over which a portable line had been slung. The strength of the pipe was indicated by the fact that the bridge remained suspended on the pipe line alone and the connection was not broken.

The only alteration in the original plan suggested by the Army was the reduction in size of the pumps to provide easier transportation. The result is that smaller pumps were located at 10 instead of 20 mile intervals.

Statistics on the Portable Pipe Line

The 4 in. line has a capacity of 6000 barrels per day. (The 6 in. line has a capacity of 10,000 barrels.)

Pipe can be laid at the rate of 10 to 30 miles per day by unskilled or regular Army personnel.

It can be operated under the supervision of a few trained operators.

No communication system is necessary because of the automatic cutoff and because only one kind of product is shipped through each line; a separate line is laid for each type of product so as to avoid dispatching complications under battle front conditions.

The light weight flexible pipe is made in 20 ft sections and each section, weighing only 90 lb, can be readily lifted and carried by one man. The pipe is spiral welded. The ends are grooved for couplings.

The total weight per mile including pumping stations is approximately 13 tons. As the line is laid, gasoline can follow along immediately through the pipe. Maximum rate of filling the line is about 2.5 miles per hr.

The cost of the material (not including transportation or labor) is about $3000 per mile.

Gasoline fueled engines operate the pumps; they were originally mounted on rubber tired trailers for quick and easy movement, but in order to save rubber the Army ruled that they were to be placed on skids instead.

Being flexible, the pipe line is not nearly so vulnerable to bombing as a rigid pipe line. Also, damage caused by bombing, sabotage or other mishaps can be rectified quickly.

An individual pumping station, if put out of action, can be replaced in a few hours.

Inside the War Plant Boiler:

BOILER WATER TREATMENT

By Kalman Steiner

FROM THE viewpoint of national economy in wartime, a boiler room should be operated with maximum regard to fuel efficiency, avoidance of accidental shutdown, and safety. Instinctively, perhaps, the operating engineer seeks to attain just those three results—he checks his combustion efficiency and steam utilization so as to minimize fuel consumption; he keeps an eye on boiler pressures, regulating devices, moving mechanisms, packings and gaskets, and other places and things where proper maintenance is essential to assure continuous and safe operation. Still, there is likelihood that he may overlook one of the most probable causes of fuel waste and one of the more possible threats of boiler damage—the condition of the water side of the boiler. Every engineer knows that he must watch the fire side of boiler surface and avoid soot deposit and chemical deterioration. Every engineer should also know that it is equally important to watch the water side of boiler surface, to avoid scale deposit and chemical action.

The Medium Sized Plant

In larger plants, such as central stations and major sized industrial boiler rooms, boiler feedwater treatment is usually provided in one form or another, and the necessary chemical supervision is available. Too often, however, the medium sized plant lacks both a comprehensive system of water conditioning and the services of someone trained in water chemistry. Here, in fact, the ills of omission may even be overshadowed by those of commission, for the engineer, trying to combat a problem of which he may have heard vague reference and about which dozens of amateur and quack or fraudulent commercial remedies are projected, may resort to haphazard ventures into the realm of water chemistry. Such unscientific efforts are not likely to be successful and may be more harmful than the effects of the untreated water.

What Every Engineer Should Know

Every engineer knows that he must watch the fire side of boiler surface and avoid soot deposit and chemical deterioration. Every engineer should also know that it is equally important to watch the water side of boiler surface, to avoid scale deposit and chemical action. This is particularly true in wartime in order to guard against damage of hard-to-get equipment, to conserve fuel, and to avoid production interruptions.

Mr. Steiner, a member of HPAC's board of consulting & contributing editors, reviews reasons for and methods of boiler water treatment, with information on new thought and developments in this field. The complex subject of caustic embrittlement is among the topics covered.

Fig. 1—Greatly magnified diagram of a leak, showing concentration mechanism

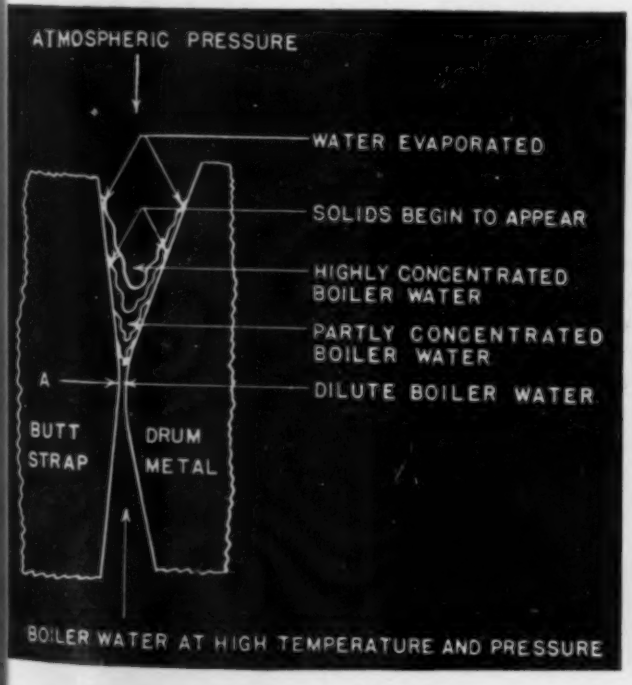
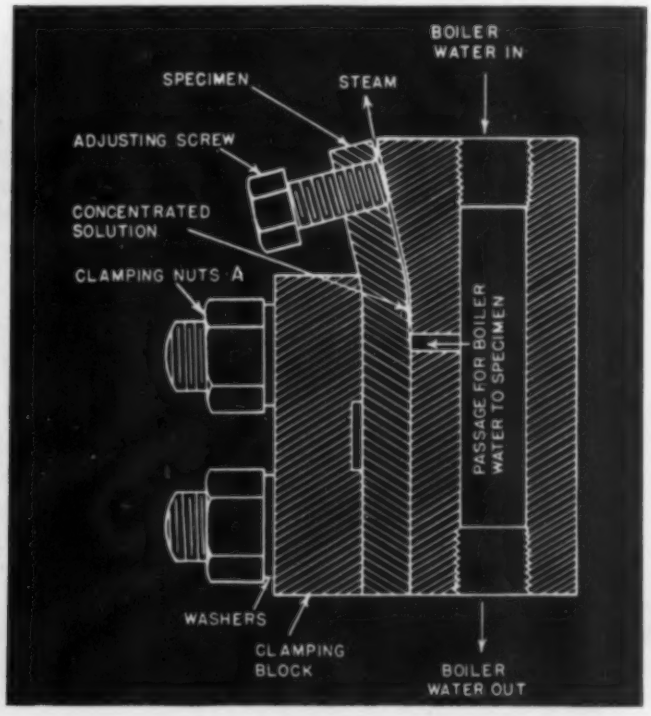


Fig. 2—Embrittlement detector (patent applied for)



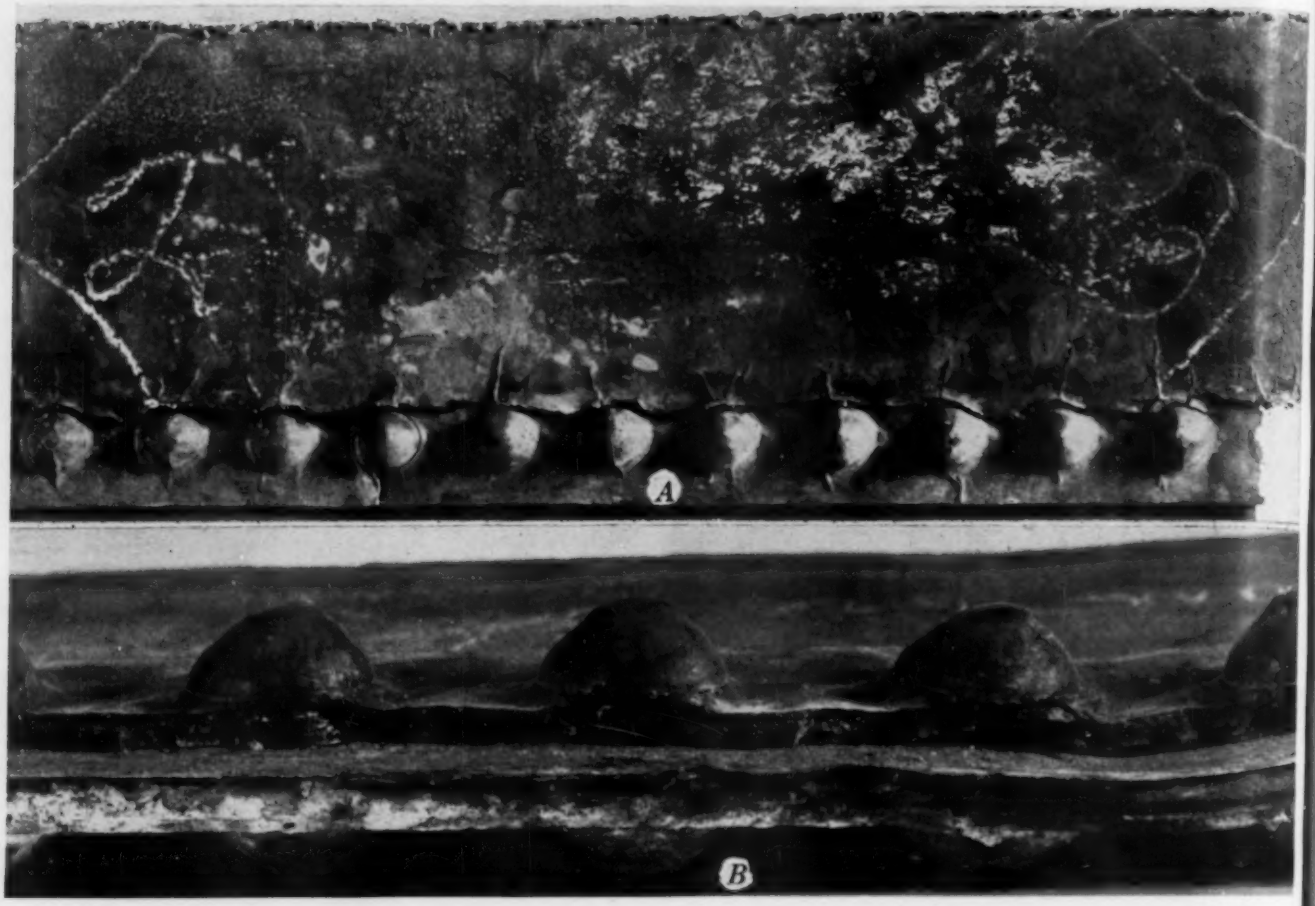


Fig. 3—Fractured lap joint: A, inside surface; B, edge view

Thrift Is Patriotism

During wartime, every reason for efficient and effective operation becomes doubly cogent. When a ton of coal is saved, it not only reduces the plant fuel bill—it lightens the load on the country's overburdened transportation, it diminishes the labor problem at the mines when labor is especially scarce, it minimizes the problem of ash disposal. Or if the fuel happens to be oil or gas, every saving accomplished by the engineer is a definite contribution to the war effort, for the first is already rationed and the second may be. As never before in our history, thrift is patriotism expressed in a most forceful and concrete manner.

The paramount thought in industrial plants today is production. This applies equally to those plants which have been specially erected to produce war materials and to those which have been converted from peacetime to wartime functions. The latter plant, however, is more likely to have developed and have in use some type of water treatment, since previous experience with the prevailing water supply should have shown what scale forming or corrosive or embrittling properties it possessed. On the other hand, many factories constructed during the past two or three years as defense or war plants may have been designed for relatively temporary use and so may not employ adequate means of counteracting improper boiler water conditions. Unless consideration is given to the matter, their boilers may be suddenly shut down through injury resulting from scale or other chemical action on the water surface. A ruptured tube or rivet seam, entailing boiler shutdown, may in turn mean interruption of vital production in the factory.

The rather broad subject of water chemistry and water treatment was reviewed by the author in collaboration with Ralph A. Nelson in the March and July, 1940, issues of HPAC. It was brought out that practically all water supplies contain some minerals or gases in solution or carry some solids in suspension, and that some type of water treatment is required of almost all boiler feedwaters. Actual methods of treatment were also considered, and it was shown that there are two general classes, internal and external, the former being accomplished by introduction of chemicals into the boiler and allowing the ensuing reaction to occur inside the boiler, whereas external treatment involves application of chemicals to the raw water in separate apparatus before the water enters the boiler. In general, internal treatment is best suited to the needs of medium sized plants. At the present time, however, a larger plant would find it difficult to arrange for prompt installation of water purifying equipment, and should it be found that its water supply requires treatment, it may be that a system of internal treatment should be instituted forthwith.

First Step—Analysis

The first step toward investigating the need of a plant for water treatment is to have an analysis

made of its water supply. In this regard, a few comments may be helpful. The methods of water analysis are fairly well standardized, but the manner of reporting the analysis, until quite recently, had not been standardized at all. Furthermore, the interpretation of the analysis still leaves much room for confusion. In quantitative analysis of inorganic solutions, the chemist actually determines the percentage composition by separate radicals; i.e., calcium (Ca), carbonate (CO_3), chloride (Cl), etc. Hence it is necessary to report actual compounds by a computation that assigns certain more or less arbitrary combinations of radicals. Obviously, there is possibility of variance in opinion as to just what procedure to use in coupling up metallic (cation) radicals with nonmetallic (anion) radicals. Because of this variance, a wide divergence may appear in analyses made on the same water by different laboratories. In an effort to dispel this confusion, a number of authorities, including the American Society for Testing Materials,* have established that water analyses shall be reported only as showing separate radicals or ions.

If by thus ignoring an annoying aspect of water chemistry there were an important objective gained, the move would be welcomed. True, on the new basis there should be little disparity between several analyses submitted on the same water by different laboratories. But from these presumably identical analyses it is necessary to proceed to an interpretation. The fundamental purpose of a water analysis, so far as boiler feed is concerned, is to predict what effect the dissolved and suspended matter will have, and what steps must be taken to counteract ill effects. It is to be hoped that either some government bureau or some national technical society will set down definite rules for translating the analysis report into a prediction of how the water will behave as a boiler feed without involving a ponderous amount of chemical calculations or discussions.

For a discussion of the impurities commonly encountered in water supplies, of their tendencies toward scale formation, corrosion and embrittlement, foaming and priming, the reader is referred to the articles mentioned above which were published in the March and July, 1940, issues of HPAC. A few remarks on recent developments in the art of water treatment will bring this previous discussion up-to-date.

*ASTM Standards, 1941 supplement, part 3, p. 247 (ASTM designation D 596-41).

Recent Developments in Water Treatment

One of the most notable advances has been the production of a synthetic organic or non-siliceous zeolite.† The term "zeolite" originates from a mineral of that name which has base exchange properties, whereby a water containing calcium or magnesium in contact with the mineral exchanges those scale forming bases for sodium and emerges with a corresponding sodium salt in solution. Subsequently, synthetic silicates were made with similar and perhaps improved base exchange qualities. Both natural and synthetic zeolites tended to increase the silica content of a water supply, and neither could be used with waters strongly alkaline or even weakly acidic, so that waters suitable to zeolite treatment were confined to a rather narrow range of hydrogen ion concentration (pH). The newly developed carbonaceous zeolites possess two important properties long sought: Inertness to alkalies or acids and consequently suitability to either a sodium cycle or a hydrogen cycle. The sodium cycle begins with the exchange of calcium or magnesium in the water for the sodium of the zeolite, and is completed, upon exhaustion of the available sodium in the mineral, by regeneration of it with a brine solution, replenishing the sodium. The sodium cycle may then be repeated indefinitely by alternation of softening and regeneration. The hydrogen cycle is similar, except that regeneration is performed with an acid and during the softening operation the calcium and magnesium are replaced by hydrogen to form an acid with the remaining radical in the water.

The great advantage of the hydrogen exchange instead of sodium exchange lies in the fact that the total of dissolved solids in the boiler feed after treatment is reduced. In addition, the process offers a means of reducing the alkalinity of a water, which in many cases is desirable. Finally, the introduction of CO_2 into the boiler is restricted. Calcium carbonate, for instance, is converted by hydrogen exchange into carbonic acid, which is readily decomposed by heat into CO_2 and water. The CO_2 is expelled in a vented feedwater heater or by some other degasifying means. Simultaneously, therefore, the total solids are reduced, the alkalinity is lowered, and CO_2 is eliminated. Sodium carbonate, which cannot be removed from solution by any treatment except heat, which converts it into the far more harmful sodium hydroxide (lye), is likewise converted to carbonic acid by hydrogen exchange and thus disposed of in a similar manner. However, metallic chlorides and sulphates are converted by hydrogen exchange into hydrochloric and sulphuric acids, which are highly corrosive, and these must be neutralized before entering the boiler. One convenient way to accomplish this is to pass part of the raw water through a sodium exchange zeolite softener, thereby forming sodium carbonate, and combining this treated water with that from hydrogen exchange treatment to effect a neutralization. By this or other neutralization, it is possible to control the alkalinity or pH of feedwater at any desired point. For application to the sodium softening cycle these new organic type zeolites have the marked advantage that the range of pH may be broadened, and there is no likelihood of increasing the silica content of the water.

As will be brought out below, the avoidance of increase in silica content is important from the aspect of boiler steel embrittlement. The hydrogen softening cycle contributes another factor in this regard; the destruction of carbonates increases the sulphate-carbonate ratio.

Corrosion an Ever-Present Hazard

Corrosion is an ever-present boiler hazard. Primarily, it is due to the presence of oxygen in the feed. Every effort should be made to remove oxygen before the water enters the boiler. Dissolved oxygen, like carbon dioxide, can be almost completely expelled from solution by

†Carbonaceous Zeolites—An Advance in Boiler Feedwater Conditioning, by H. L. Tiger, ASME Transactions, vol. 60, p. 322.

heat. A good deaerating feedwater heater, by raising and holding the water at boiling for a sufficient number of minutes, and by properly venting the expelled gases, will reduce the residual dissolved oxygen to about 0.03 ppm. For disposing of that oxygen which has not been or cannot be removed from the feed, various reducing chemicals have been used with excellent results, including sodium sulphite, iron, ferrous hydroxide, and a number of organic compounds. The most commonly used is sodium sulphite. Research has demonstrated that this chemical can be used without danger.**

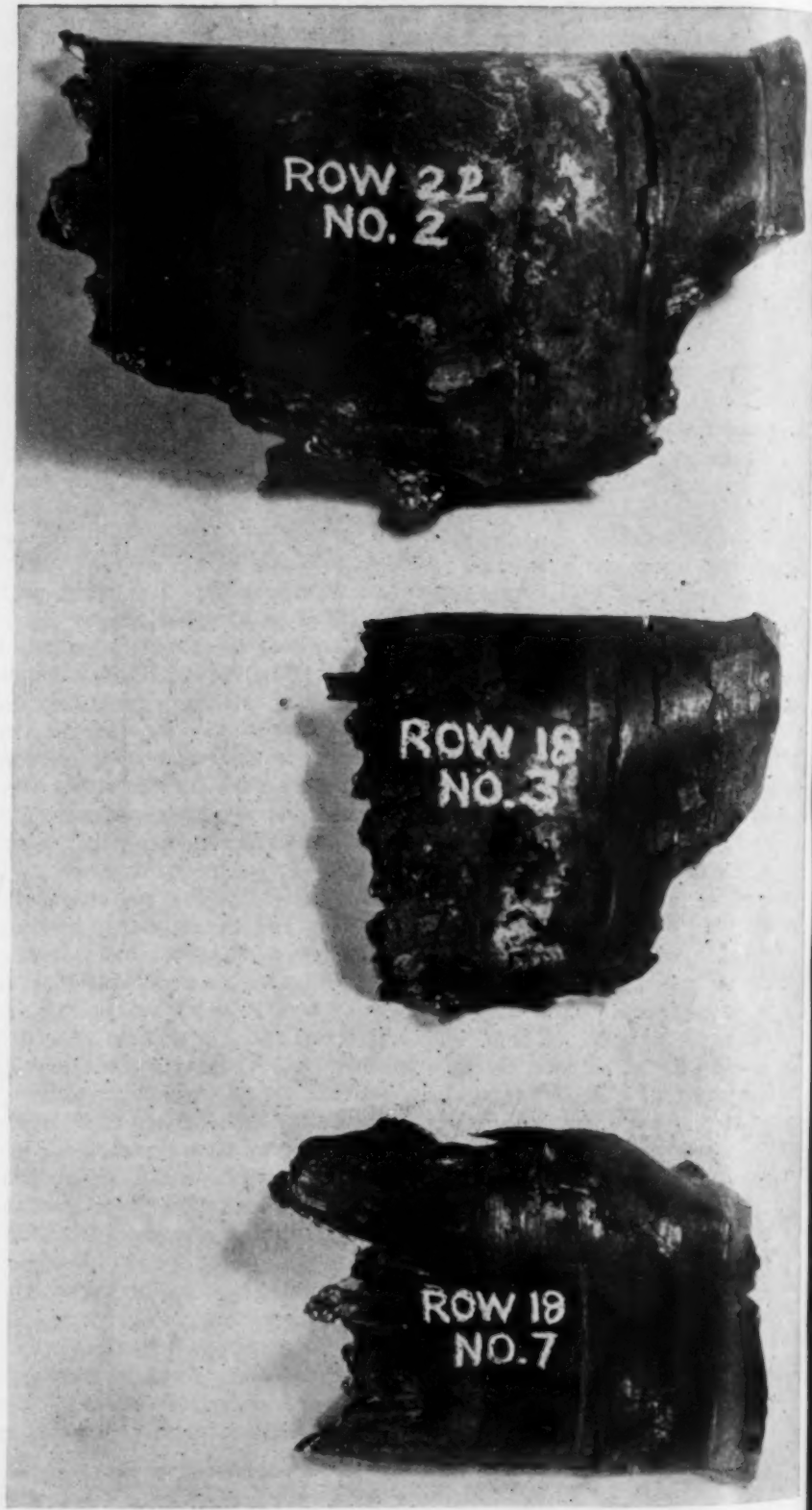
Caustic embrittlement continues to be a topic of live importance. Probably the greater part of all research in boiler feedwater is devoted to it. This is because it has been the most baffling aspect of boiler metal failure. Recently published data not only throw much light on the subject, but reverse much that was heretofore thought true. For instance, the ASME has published instructions for the maintenance of a sulphate-carbonate ratio which was thought to provide protection against caustic embrittlement. The Bureau of Mines has now published information which casts doubt upon the infallibility of this ratio to assure protection.†† The bureau's work has been carried out under the auspices of a subcommittee of the joint research committee on boiler feedwater studies, sponsored by several national organizations. As recently summarized*** by the chairman of the subcommittee, J. H. Walker, the project has included investigation both as research at the bureau and practical applications in the field.

Caustic Embrittlement a Complicated Subject

It now appears that embrittlement is a very complicated subject, and is not restricted merely to water chemistry. Such factors as character of the boiler steel, stress of the boiler metal, method of boiler construction, bear much weight in embrittlement. No simple solution to an embrittlement problem appears possible, but some protective procedures have been worked out. These preventive measures will be better understood from a brief study of the embrittlement conditions.

Embrittlement failure or intercrystalline cracking of boiler metal occurs only where the metal is under internal or external stress from cold working such as forming or riveting, or from distortion

Fig. 4—Embrittled tube ends from a water tube boiler



**The Behavior of Sodium Sulphite in High Pressure Steam Boilers, by R. M. Hitchens and J. W. Purssell, Jr., ASME Transactions, 1938.

††Bureau of Mines Bulletin 443, 1941, Intercrystalline Cracking of Boiler Steel and Its Prevention, by W. C. Schroeder and A. A. Berk.

***Caustic Embrittlement Research Brings Results, Mechanical Engineering, December, 1942.

such as unequal expansion or contraction. The design stress resulting from internal steam pressure is not a factor.

A small leak must exist to permit the slow passage of boiler water and gradual evaporation of the water to leave behind a high concentration of boiler water chemicals trapped in a restricted region around the leak. Such leaks usually exist at the rivet seams, where the metal also is likely to be under stress.

The water must contain embrittling chemicals—sodium hydroxide and sodium silicate with no inhibitor. The presence of silica in boiler water was not heretofore considered to render it embrittling, but it now seems reasonably certain that, especially at higher steam pressures, it does.

From the above analysis of embrittling conditions, it would seem that if new boilers are constructed by welding the seams and properly stress relieving the metal, the probability of embrittlement will be eliminated. The use of steel compositions known to be specially resistant to this type of cracking is also to be recommended.

But the most important consideration is the protection of existing boilers against cracking. First, riveted seams should be carefully inspected and any obvious leak closed up by calking. But leaks too small to detect visually will continue to permit flow of water and accumulation of highly concentrated alkaline solutions, and therefore corrective action must be applied to the boiler water. For a number of years sodium sulphate has been used, as above mentioned. Probably in most cases of stationary boilers the sulphate will give the necessary protection. In locomotive practice it has been definitely established that sulphate will not protect a boiler against cracking, and even in stationary practice there is enough evidence to throw doubt upon the complete efficacy of sulphate. The bureau's work shows sodium nitrate to be a dependable preventive against both sodium hydroxide and sodium silicate. However, sodium nitrate should be used only under the direction of a trained water chemist, for this substance in low concentration can actually accelerate cracking. The dosage must be carefully determined and maintained and amateur handling might prove disastrous. Sodium phosphate has been considered for embrittlement prevention. This substance has its usefulness in controlling alkalinity or pH and so indirectly affects concentration of sodium hydroxide. Sodium phosphate has definite usefulness in water softening and alkalinity control, but it is not an inhibitor of embrittlement should hydroxide or silica be present also. Finally, certain organic materials have definitely been established as positive inhibitors, notably tannin substances obtained as byproducts from the cellulose, tanning, and dyeing industries.

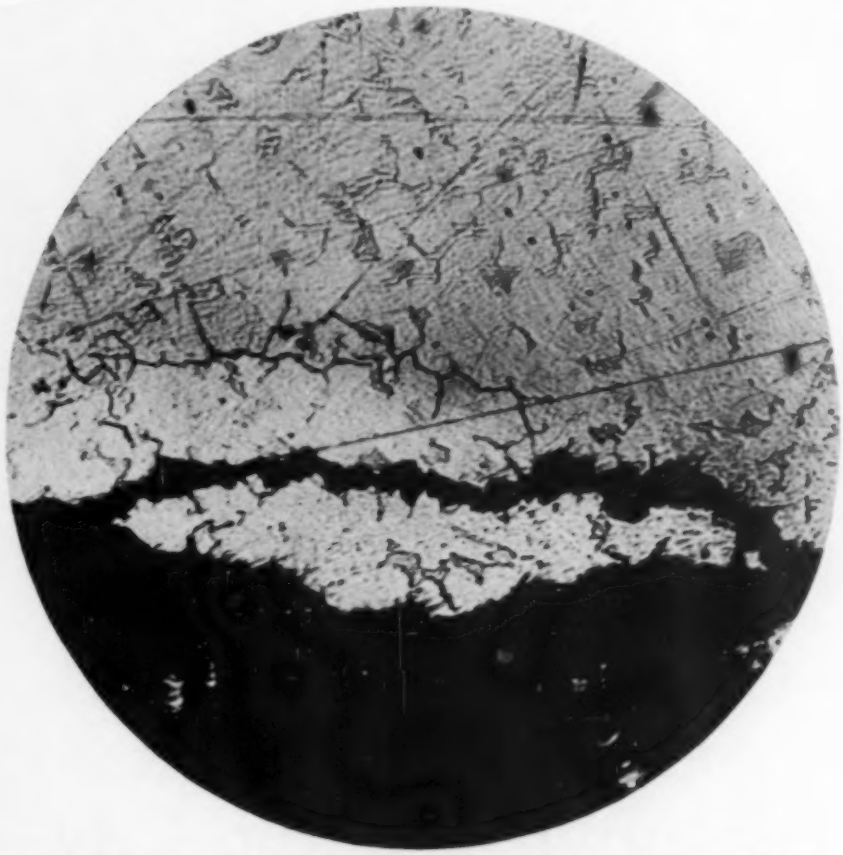


Fig. 5—Intercrystalline cracks in tube ends of a low pressure boiler (500 X)

Predicting Caustic Embrittlement

The complex chemistry that apparently is involved in caustic embrittlement would seem to make it difficult to predict the action of a water supply with regard to tendency to cause cracking. The Bureau of Mines has developed a method for determining this experimentally. It consists of an apparatus that subjects a piece of steel, of the same composition as the boiler metal, to the action of concentrated boiler water. Fig. 1 shows diagrammatically how a small leak permits rapid and high concentration of boiler water chemicals. Fig. 2 illustrates the test mechanism which may be attached to the boiler for the purpose of duplicating the action that would occur at a small leak; the test specimen is placed under stress by turning the adjusting screw. When subjected to the action of embrittling water the steel usually fails within 30 days. The apparatus is patented by the Bureau of Mines, which extends the privilege of use to all but suggests that it be consulted before an application is attempted.

[All illustrations reproduced by permission from Bureau of Mines bulletin 443, Intercrystalline Cracking of Boiler Steel and Its Prevention.]

* * *

It is good business, as well as your patriotic duty, to save fuel—coal, oil, or gas—by heating efficiently. Uncle Sam wants you to fight waste!

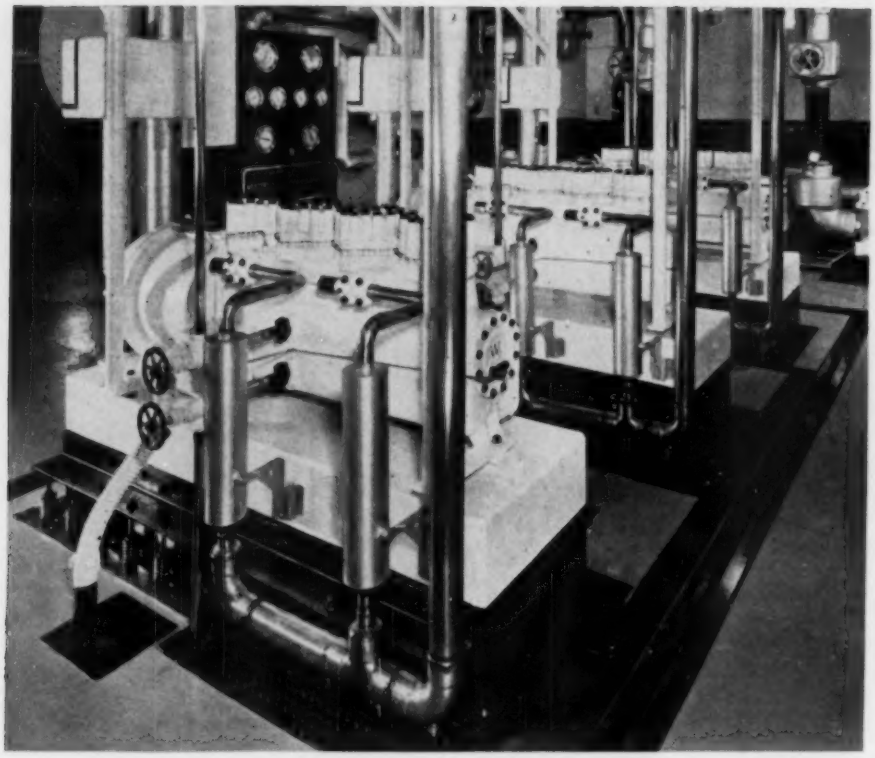


Photo courtesy Westinghouse

There are three 40 hp refrigeration compressors

Conditioned Air Can't Go On the Air at Hollywood Radio City

Harry C. Alber, Building Supervisor and Air Conditioning Engineer, Radio City, Describes Conditioning System That "Floats on Springs"

EVER SINCE the building was completed four years ago, the air conditioning system that "floats on springs" at the National Broadcasting Co.'s west coast headquarters, Radio City, Hollywood, Calif., has been in continuous, trouble-free operation and maintenance has been normal. The system is completely sound and vibration proof. For this reason the rush of the 95,000 cfm of air "can't go on the air" over sensitive microphones in the numerous studios.

Heart of the system is the refrigeration center, where water from an 85,000 gal tank is cooled to 35 F in a cooler through which "Freon" liquid is expanded to a gas. There are three 40 hp compressors operating at 1155 rpm.

Our records show that maintenance throughout the four years has comprised routine changes of filter elements. The compressors and the motors powering them have at no time been down for repairs. All compressors, pumps, pipes, and other operating machinery float on wood or concrete "islands" supported by vibration isolation. The compressors and pumps are further isolated from the floor by a set of coil springs for each unit. The purpose of this installation is to prevent possible transmission of motor and fluid surge vibration through beams and walls into the broadcasting studios immediately above and adjacent. Similarly, all piping and air distribution ducts are suspended from the ceiling by strap and spring fixtures.

Conditioned air is "mixed" before entering the main blowers. Musical instruments and delicate radio mechanisms are sensitive to temperature and humidity variations. Thus, conditioned air must be carefully controlled and held to an average constant throughout the building. Humidity is maintained by an especially designed unit placed directly in the air path to the supply duct. Air drawn in by the blowers passes through this chamber, in which city water is sprayed over live steam coils.

By placing the humidifier before the blower there is no uneven distribution of humidity within the conditioned space. Controls are so placed that air cannot become saturated. A further control of heat and humidity is the covering of the ducts. The outsides of all distribution ducts are wrapped with canvas covered cork sheets. This minimizes possible loss of heat and prevents condensation.

Sound is absorbed in this system primarily by the spring suspension of all motors, pumps, and fans which may produce vibration. To gain further advantage of this mechanical means of sound control, all distribution ducts are lined with balsa wool and there are baffles in return ducts to deaden noise originated in the apparatus.

As a further aid to efficient operation and maintenance, a time clock guarantees operation of the system at irregular hours. According to War Department requirements, broadcasting might occur at odd night hours. The time control is then automatically adjusted with the main electric power supply of the building so that air conditioning apparatus will function at a predetermined period.

A draft gage registers air flow resistance from which the amount of dirt collected by the filters can be determined. Thus inspection of the filter units is accomplished by taking dial readings rather than opening the door to the supply duct. This provides maintenance insurance and lowers filter costs in that filters are changed only when dirty, and not at periodic intervals.

A HISTORY of PIPING

M. A. Hasselmann Continues Interesting Description of the Development of "Greatest Transportation System"

THE MANUFACTURE of lap welded and butt welded wrought iron pipe was developed in England between 1812 and 1825 and begun in America around 1830. As a result, wrought iron pipe became an important competitor of cast iron, wood, and lead for water systems. About this time, too, the threading of pipes was developed. The screwing of one section of pipe into the bell of another (rare) or into a separate sleeve type coupling or fitting (common) gave a good connection.

As the size of rolled wrought iron sheets was increased, the sizes of wrought iron pipes were increased. Seams and sections were joined by riveting or by hammer welding. The techniques developed in making wrought iron tanks, boilers, etc., enabled making larger wrought iron pipe than could be cast—at least for anywhere near the same money. In 1840, pipe with a wrought iron shell with riveted seams and a cement lining was developed and was used extensively, especially in New England. Large wrought iron pipe was introduced in California in the 1850's for hydraulic mining and as a result it—and later, steel pipe—got a hold on the Pacific Coast water systems which has always been retained.

The first riveted wrought iron pipe with bituminous protective lining and coating was used at Rochester, N. Y., in 1870. Such a main laid in old Charlestown in 1871 was still in use in 1926 as part of Boston's system.

With the development in the latter half of the last century of the Bessemer and open hearth methods of making steel, large pipe made of sheets of steel gradually became more generally used. After 1887, when butt welding was successfully applied to steel, steel pipe became a commonly used material for water lines.

Copper and brass piping for residences and buildings was begun after 1838 when a mechanical means for forming seamless brass tubing was introduced (casting, then drawing). The first installation of record is the Old Parker House, in Boston, built in 1854. However, the use of brass and bronze piping in this manner did not become common until this century.

Concrete piping for water mains became an important material after the turn of this century. Reinforced concrete was introduced in this country about 1905 and since 1912 concrete has been regarded as a good material for mains and aqueducts where pressures are not too great. Both types—poured in trench around collapsible molds, or preformed pipe sections—have given encouraging results from the standpoints of prevention of leakage, maintenance of capacity, and first cost.

In recent years asbestos-cement water pressure pipe has been used in this country with success.

Scientific Discoveries Aided

During the latter half of the 1800's a number of scientific discoveries stimulated the building of better water systems, and the use of better piping systems. Most resultful of these were the discovery in 1850, by Dr. A. H. Hassall of London, of identifiable microscopic living organisms in water, and Dr. Koch's discovery. Dr. Robert Koch of Germany, in 1892, showed the cholera epidemic then prevailing in Hamburg to be due to contamination of the city's raw river water by the cholera germ.

By 1893, chlorine was applied to sewage that was contaminating the water at Croton. In 1903 Lt. Nesfield of the Indian medical service applied liquid chlorine gas to drinking water.

Since 1892 the purification treatments we know today were either originated or perfected: sedimentation, coagulation, filtration, disinfection, sterilization, aeration, ozonation, and violet rays. The net effect of the building of purification plants has been the addition of large requirements for piping. Also, purification has made anything less than good mains with good joints ridiculous.

First Modern Sewer

In ancient times and modern, the first sewers to be built were those that got rid of particular nuisances, surface water, or sewage—usually in the business areas or the better residential districts. It was not until 1876 that Hamburg, Germany, had completed the first modern sewer system as we know it today. Every street had a sewer and every residence and building was required by law to connect to that sewer.

The early sewers in Europe and in this country were made of wood, brick, stone, or brick and stone. Mortar wasn't always used. Typical construction for small sewers was a stone bottom, brick sides and a bridging stone top. Large sewers had flat bottoms with straight sides at right angles and arched tops, or just flat bottom and arched top. The materials were rough, hard to keep clean and required frequent repair. However, the major faults of these early sewers were in design and construction, not materials—the ancient Romans had built model sewers with these same

Deserves History

Piping—from the "Big Inch" line just completed for supplying oil and gasoline to the east, to the small diameter tubing transmitting pressure to operate a process control — represents man's greatest transportation system. As such, it deserves to have its history written, which is the job Mr. Hasselmann, of Tube Turns, Inc., set himself.

This month, in the fourth of a group of articles in Heating, Piping & Air Conditioning, the author covers piping materials for water supply and sewer systems, and by means of sketches traces the development of pipe connections through the ages.

DEVELOPMENT OF PIPE CONNECTIONS THROUGH THE AGES

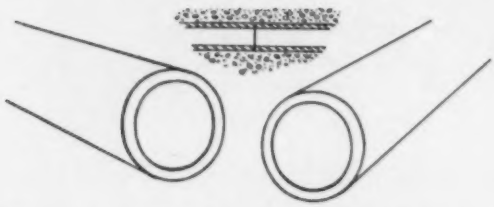


Fig. 1—To hold pipes in line and prevent leakage between connections, the ancients of 3000 B.C. encased them in cement

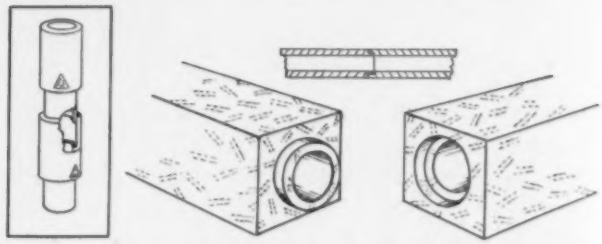


Fig. 4—Each section of carefully made stone, baked clay (inset), and terra cotta pipe of this period—400 B.C.—had an extended lip at one end and an indentation in the other. Thus sections fitted together tightly, especially when a sealer was used. Romans used a mixture of lime and oil as a seal

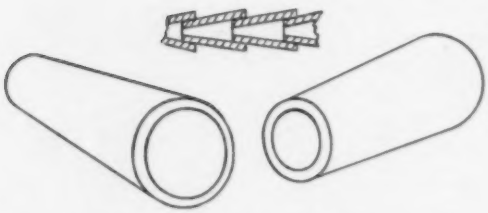


Fig. 2—The palace of King Minos, 2000 B.C., which had latrines and baths on the second and third floors, was piped with tapered pipes like these. They were of terra cotta

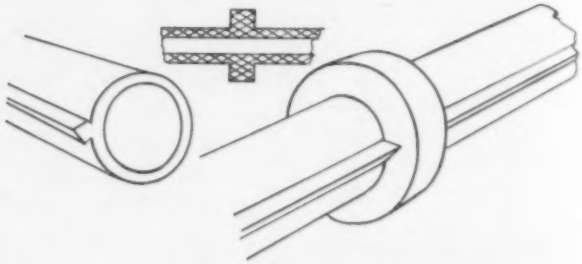


Fig. 5—The Romans in 200 B.C. used a great deal of lead pipe, joining it into watertight connections as strong as the pipe itself. These connections were cast lead collars which fused the two ends of pipe

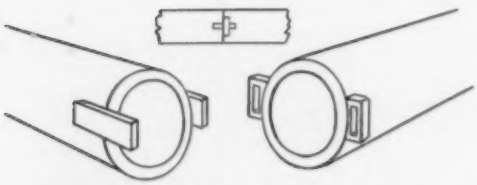


Fig. 3—To hold pipes in position the ancients of 500 B.C. devised piping with 2 in. cusps on one end and rabbets on the other. The cusps fitted into the rabbets; clay sealed the connection

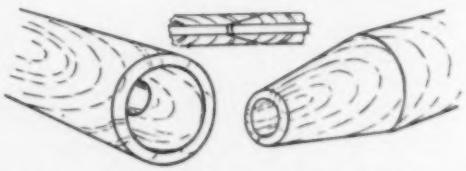


Fig. 6—The little piping of the Dark Ages, for wells and the simplest castle water lines, were of wood—bored logs with conical ends that fitted into conical shaped indentations

materials. The sewers did not incline properly, were not adequate, were carelessly built. In England especially, sewers were considered too disgusting for better minds to concentrate upon and their planning, like their construction and maintenance, was left to the uneducated. No wonder Englishmen spoke of "sewers of deposit"; it was assumed that sooner or later all sewers would cease to function at all!

The early sewers were built by individuals or groups who ran them to some ditch, river or harbor's edge, or, if they could get away with it, just off their own property. There was so much trouble—arguments between partners, irresponsible trench digging across streets, poor sewer construction, etc.—that in 1701 Boston passed a regulating law, the first of its kind, endeavoring to bring order from all this strife and confusion. The law called sewers "drains and common shores" and required that sewers "be substantially built with brick and stock (stone)."

In 1823 Boston, a leader in America in sanitary progress, took over control of all sewers and their maintenance and the construction of new sewers. Costs were charged back to the property owners benefiting, minus a certain amount representing the city's share for the draining of the streets. It was not until a decade later that Boston permitted fecal matter to enter into its sewers—this had to wait for water carriage.

In 1845, in England, glazed stoneware, or vitrified clay, drain and soil pipe as we know it today, was introduced. These were joined with clay for the following 30 years, after which cement began to be used. The first clay sewer pipes used in America appeared in the 1850's and were made on the potter's wheel. Soon after, they were molded. A little later they were pressure molded by steam power, in much the same way they are made today.

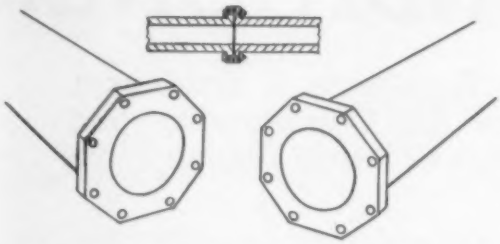


Fig. 7—Cast iron pipe of the 1660's with octagon shaped flanges cast integrally at both ends of each section. Joints were gasketed with lead and held with wrought iron bolts through bolt holes cast in the flanges. Some cast iron pipe and many fittings are made this way today except that the flanges are round

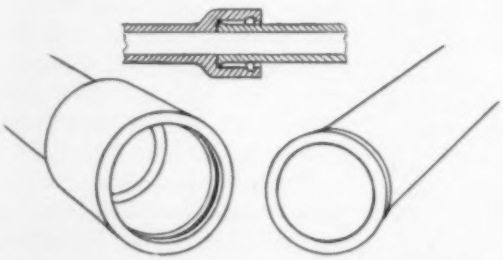


Fig. 8—The bell and spigot joint of 1785 for cast iron pipe. The packing inside the bell and around the spigot was lead or clay. Later, impregnated yarn was used as a seal and various combinations of materials, eventually shredded lead. Baked clay piping, coming along 50 years later, was usually belled but not spigoted, and today is sealed with various cements

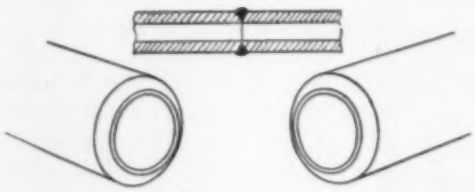


Fig. 11—Welded pipe connections, 1927. The two machined ends of pipe (or fittings) are butted together and welded with a V-shaped weld that is stronger than the pipe itself

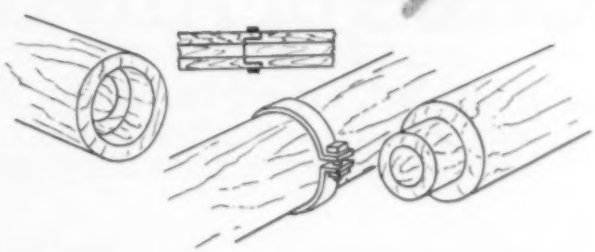


Fig. 9—Bored logs with wrought iron bands reinforcing the joints were used in America around 1800. Some systems had wrought iron inserts between connecting logs, with reinforcing bands (one on each log at each connection). When wood stave piping was introduced some 40 years later, it was jointless—ends of staves were staggered

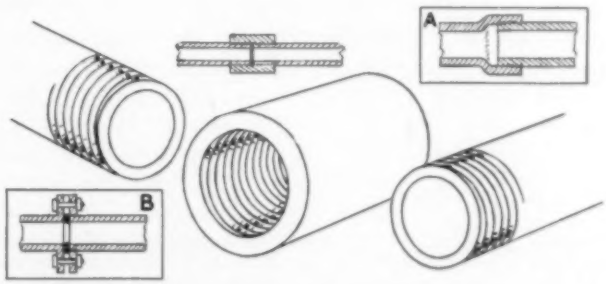


Fig. 10—In 1825 the forming and welding of wrought iron pipe by the welding bell method was begun in England. Putting bell and spigot ends on this pipe required an extra operation and the idea of threading a short section of larger wrought iron pipe (also cast iron turns and tees) and screwing in the threaded ends of the pipe, came into being. Some bell and spigot pipe was threaded (see inset *A*) and such is not uncommon today. Threading and attaching a separate flange (inset *B*) became a logical solution when sections of flanged-at-both-ends pipe had to be cut. This led to the various types of connections made with separate flanges in use today

Wood stave sewers were common up to the fourth quarter of the last century. A civil engineer writing in 1884, however, explained that their use by that time was almost extinct except in the far west. Where wood stave sewers were required, treated (creosoted) alder, beech, elm, larch, oak, and teak were recommended.

Rarely was expensive iron pipe "wasted" on sewage lines until well into the last century and in this country. During the 1850's, cement lined wrought iron sewer pipe was common for the smaller sizes, brick being used for the larger sizes.

By 1880 a separate cast iron soil pipe industry was well established here. This pipe was often cast half-section; one section was used for the bottom and one for the top of a house-to-street sewer line. A writer of that period, after explaining how the best houses of 40 years before "had no better plumbing than the best houses of Paris do today," described the best piping of his day: "The kitchen and wash-bowl drains usually begin as small lead pipes; these lead to larger iron pipes and these lead to the main channel, sometimes iron and sometimes earthenware. Lead pipes are usually tight. Iron pipes are connected funnel-wise (bell and spigot) so that whether tight or not the water runs away. Leaky joints in iron pipe, though still by no means uncommon, are less frequently found since attention has been given to testing joints under pressure. The best joints are formed by India rubber rings held between two plates, the plates drawn together with screws."

Cement has been used for sewer piping in this country ever since the construction of modern sewers (using water carriage) became general. The first such installation was made a hundred years ago at Mohawk, N. Y. A significant installation of cement sewer piping was made at Washington, D. C., in 1885, the first large sewer of concrete.

ACRES of AIR CONDITIONING

H. E. Ziel, Associate, Albert Kahn Architects & Engineers, Inc., Briefly Describes Some of the Air Conditioning and Ventilation at the New Chrysler Dodge-Chicago Engine Plant

WAR PLANTS present many problems in air conditioning not only because of their immense size, but also because of the materials to be processed in them and the extremely close tolerances required. Many of these plants are several times as large as those which only recently were considered vast, the metals to be worked in them are strange to a majority of those who will man the plants, and the tolerances are close to plus or minus zero. The new Dodge-Chicago Plant Division of Chrysler Corp.—financed and owned by the Defense Plant Corp. and operated by Chrysler Corp.—which was designed by Albert Kahn Associated Architects and Engineers, Inc., in co-operation with Chrysler engineers is an example.

Airplane engines are to be manufactured and assembled in this plant, and the use of magnesium, aluminum, and steel in airplane engines requires more exacting temperature control within certain areas than has heretofore been considered necessary in the automotive industry. The coefficients of expansion of the above mentioned metals are not at all similar. Thus, with an appreciable rise in temperature within the working area, difficulties are encountered in assemblying parts of these dissimilar metals. It is, therefore, necessary to control the temperatures in certain areas and not allow the dry bulb temperature in the machining or assembly area to exceed 85 F.

This area in this aircraft engine plant—which, incidentally, is only a small part of one building—is equivalent to more than 20 acres of floor space; the temperature is controlled by means of 81 air conditioning units handling a total of over a million and a half cfm of air. The air conditioning units are on the roof. (The roof of this building is of a type of construction developed by the Kahn and Chrysler organizations).

Each of the 81 fan units handles and conditions 21,000 cfm of air. The cooling is accomplished with a 60 ton radial type refrigerating compressor placed in close proximity to the air conditioning unit and the evaporative condenser.

The ease in supporting the air conditioning system, due to the type of roof construction, made it appear more desirable to use the unitary system of cooling, rather than a central system of cooling and heating. The unitary system has the advantage of obtaining greater flexibility in maintaining suitable temperature control and reduces the quantity of large size piping, which is so critical at this time.

The systems will normally recirculate 75 per cent of the air, but 100 per cent outdoor air can be handled during "between season" operation. Complete automatic change over of operation from summer cooling to winter

The attention of so many who view the huge Dodge-Chicago plant from a distance is first attracted by what appears to be a towering concrete silo. That is the first of a new type of water tank construction, two of which are being provided. The tank itself is made of cypress, and is mounted 125 ft above grade on a cylindrical tower of reinforced concrete. Over 60 tons of steel were saved by using concrete and wood. The pump pit is inside the base and no frost casing is necessary because water pipes are entirely enclosed within the tower. There is also a ladder, with landings at intervals, inside the tower. And finally, provision has been made for hanging 100 ft lengths of fire hose inside to drain

ventilation is accomplished without manual switches.

This section of the main building is always under pressure and all air leakage is outward. There is a series of relief dampers on the roof controlled by the outdoor intake dampers when 100 per cent open. The air distribution is by side blow outlets.

The heating for the air conditioning units is obtained by steam heated coils controlled by room thermostats which operate bypass dampers and thermostatic valves. Each air conditioning unit is directly above the area which it supplies. Therefore, each unit can readily adjust itself to the area which it supplies.

The air conditioning problems in the basement space are unusual due to the extreme areas covered. Locker rooms, cafeteria, kitchens, shower, and toilet rooms are placed in this basement area along corridors which reduce the time required for the employees to reach their departments when at the start of their shift period.

The large areas in this basement make it highly desirable to recover a maximum quantity of air for the purpose of reducing the intake and exhaust shaft sizes, and the steam load (thus reducing fuel consumption). With the use of air recovery by means of odor adsorbers for cafeteria and locker room areas, these economies are fully realized.

The heating, ventilating, and air conditioning contractors on this project are Mehring & Hanson Co., Phillips-Getschow Co., Narowetz Heating & Ventilating Co., and R. B. Hayward Co.

New Problems

Because of their immense size, the materials processed, and the close tolerances required our new war plants present numerous air conditioning problems. At the new Dodge-Chicago Plant Division of Chrysler Corp., where large aircraft engines will be manufactured, 81 air conditioning units handling over a million and a half cfm of air serve the machining area which —though but a small part of one of the buildings—is equivalent to more than 20 acres of floor space.

There is also basement area air conditioning, with air recovery by means of adsorption equipment.

Overfire Air Jets Effective for Smoke Elimination

INCREASED RATINGS from existing coal fired furnaces, more complete combustion, and the prevention of smoke are indicated as the result of studies on steam-air jets for Bituminous Coal Research, Inc., by R. B. Engdahl and W. C. Holton of Battelle Memorial Institute. Their report, presented at the spring meeting of the American Society of Mechanical Engineers, outlines the design dimensions and performance of steam air jets over the practical range of sizes and pressures.

Jets of air directed over beds of burning coal have been known to be effective for many years in completing the combustion of hydrocarbons that leave the bed unconsumed. When properly located and directed the jets supply air with the necessary turbulence for smokeless combustion. The air may be aspirated into the furnace by high velocity jets of steam issuing from small nozzles or it may be blown in by centrifugal fans.

Not All Furnaces Require Them

Not all furnaces require overfire air jets. They have generally been added to existing installations when found necessary. Standard designs of nozzles have never been available for such construction, hence nozzles were often inefficient or ineffective.

The Battelle studies covered designs of steam air jets that would be suitable for both hand and stoker fired furnaces. Steam pressures from 48 to 170 psi were used at the nozzles. While the steam air jets were found to be less efficient than centrifugal blowers, they are simpler substitutes for the latter, especially during the present emergency when fans and motors are not readily available. Any machine shop can fabricate them from materials at hand.

The steam air jet consists of an open length of tubing passing through the furnace wall, with a steam nozzle directed axially into the outer end. The optimum length of air tube is about 7.5 times the diameter. The tube entry should be funnel or bell shaped. The optimum nozzle position is about one air tube diameter back of the throat of the air tube. A simple silencer has been devised because the bare jets are too noisy for comfort.

There is no preferred ratio or diameter of air tube to diameter of steam nozzle. With a given steam jet, increasing the diameter of the air tube will increase the amount of air delivered to the furnace. A larger steam nozzle would accomplish the same result but at a greater cost in steam.

Typical Illustration of Performance

As a typical illustration of the mechanical performance of a steam air jet, an air tube 15 in. long made of 2 in. standard pipe and supplied by a steam nozzle of $\frac{1}{8}$ in. diameter will deliver 1026 lb per hr of air into a furnace with the use of 72.7 lb of steam at 100 psi gage pressure. While the air entering the furnace is accelerated to the velocity of 10,000 fpm in the tube by the steam jet, this velocity drops to 1000 fpm about 8 ft inside the furnace. This range of velocities is very effective in promoting turbulence and good combustion.

HEATING REPAIR WORK ACTIVE

There is no freeze on the materials needed for the repair of hot water and steam heating plants, or on replacement parts, says the Plumbing and Heating Industries Bureau. The bureau points out that the WPB has recently liberalized the order controlling the manufacture of cast iron boilers so that more parts will be available during the 1943-1944 heating season.

The order, says the bureau, permits boiler manufacturers to produce as many component parts for coal fired boilers during the last six months of this year and the first six months of next year as they made during the corresponding months of 1940.

Reports from heating and piping contractors received by the bureau indicate that the public has responded to the appeal for earlier checking and servicing of heating plants. Some of the oldtimers in the hot water and steam heating business say that never in 40 years have they known so many orders for repairs and replacements to be placed in July and August.

Testing Toxic Atmospheres

N. R. Bernz Explains the Methods of Determining the Impurities in Industrial Air, a First Step in a Program for Industrial Health Conservation

FOR HALF a century or more the United States has been looked upon by the rest of the world as an industrial giant, a nation in which industrial production has surpassed every other line of endeavor. At no time, however, has the productive capacity of this country meant more to us and to the rest of the world than it does today.

We can afford no interference to operations of our industrial plants. Prevention of accidents and occupational disease becomes our duty. As an industrial hygienist, I may perhaps render some service by reviewing outstanding occupational disease hazards in war industries.

Gases

Carbon Monoxide

Carbon monoxide is a very toxic gas encountered in various industrial activities. The toxic limit for this gas is generally accepted as 100 ppm for prolonged exposure. In industrial operations involving baking ovens, drying kilns, coke ovens, blast furnaces, etc., carbon monoxide is frequently encountered. In industrial processes in general, and particularly where chemical reactions are involved, carbon monoxide may be generated as a dangerous byproduct. For instance, in prism grinding, a high quality iron oxide rouge is required. Occasionally this material is manufactured on the premises as an adjunct to the prism grinding work. This involves the use of oxalic acid for production of iron oxalate which is later decomposed by heat to yield iron oxide rouge. Carbon monoxide as well as other gases are generated in this process.

Several methods have been developed for the quantitative determination of carbon monoxide, but only the two most expedient procedures employed in industrial hygiene work are discussed here. One of these is the carbon monoxide indicator based on the catalytic reaction of hopcalite, which oxidizes carbon monoxide to carbon dioxide. The small electric current produced by the heat of the reaction through a thermocouple is calibrated in terms of carbon monoxide concentration which is read directly on the dial of a milliammeter. The source of suction in this instrument is a small centrifugal blower, the motor of which is operated either from a builtin 6 volt battery or from a 110 volt lighting circuit through a transformer. It is a very convenient and most useful instrument.

Another convenient method for estimation of carbon monoxide, though less sensitive and not so accurate, is the use of palladium chloride ampoules. In this reaction the palladium chloride is reduced to metallic palladium, thereby producing a stain the intensity of which is in direct proportion to the amount of carbon monoxide in the atmosphere under observation. The stain produced is compared to known color standards for evaluation of the carbon monoxide present. This method is not specific for carbon monoxide, however; there are other reducing gases which also will produce a stain in the presence of palladium chloride. Incidentally, the standard method for carbon monoxide evaluation, adopted by the British department of industrial research, London, and published in a series of leaflets on Methods for Detection of Toxic Gases in Industry, consists of a palladium chloride test paper through which the air to be sampled is drawn by means of a hand pump. The stain thus produced is compared with a standard color chart.

Hydrogen Sulfide

Hydrogen sulfide is a very toxic gas with a disagreeable odor. It is found in many industrial operations where sulfur or sulfur compounds are used, but primarily it is encountered in the artificial silk, chemical, and petroleum industries. Safe limits varying between 20 and 50 ppm by volume have been suggested by various authorities.

The most rapid method for determinations of hydrogen sulfide is undoubtedly the use of a hand operated instrument, consisting essentially of an aspirator bulb and a detector tube through which the air sample is drawn. The detector tube contains a chemical substance which when in contact with hydrogen sulfide produces a discoloration the length of which is in proportion to the amount of hydrogen sulfide present and can be measured on an attached scale. It can also be determined iodometrically, either by bubbling through a sodium hydroxide solution and titrating with iodine, or by bubbling through potassium iodide starch solution and

Health Conservation a War Job

In a discussion at a meeting of the National Safety Council, Mr. Bernz gave a brief description of some of the more commonly encountered toxic substances in war industries, and methods for their evaluation. The material on dusts published in the May HPAC was taken from his paper; this month, gases are discussed and in future issues will be presented the sections on metal fumes and vapors, solvent vapors, and acids.

Unless properly controlled, exposure to these materials may result in ill health among industrial workers with accompanying absenteeism and interference with war production. The control of these industrial poisons should, therefore, be an integral part of an extensive program of industrial health conservation. Such a program is of prime importance at a time when every piece of manufactured goods plays an important part in winning the war, and is of interest to ventilation engineers because ventilation is the principal method of control.

Mr. Bernz, a consulting engineer, is a member of HPAC's board of consulting & contributing editors.

a measured amount of standard iodine, in which reaction the disappearance of the color indicates the end point. This method is employed at the Harvard School of Public Health.

Hydrogen Cyanide

This gas—for which the industrial hygiene bureaus of California, Connecticut, and Massachusetts have established a safe limit of 20 ppm by volume—is found in electroplating operations, heat treating, etc.

A portable instrument of the type discussed in connection with hydrogen sulfide has also been developed for hydrogen cyanide. I have been informed, however, that the hydrogen cyanide detector in its original form proved less satisfactory and that it has been withdrawn from the market temporarily pending further research.

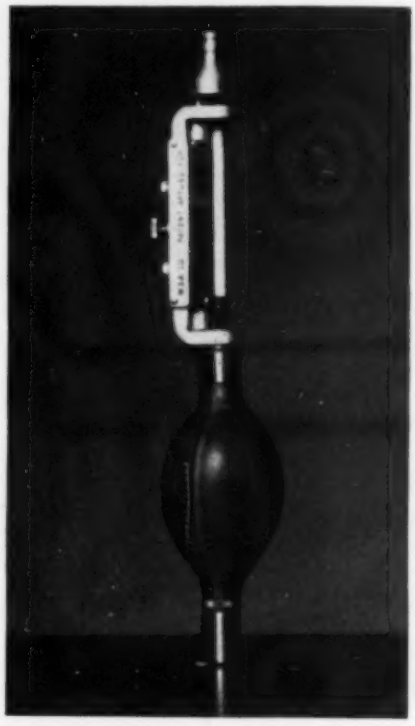
Chemical tests are available for detection of hydrogen cyanide, such as the prussian blue and thiocyanate reactions, both of which are specific for this gas but allegedly not sensitive enough for concentrations encountered in industrial hygiene work. Other methods suitable for determinations of this gas in small concentrations are the congo red-silver nitrate and the benzidine—copper acetate test papers. These methods, which have been adopted as standard tests by the British department of industrial research, are nonspecific, however, so that the possible interference of other gases such as HCl, NH_3, SO_2, and H_2S should be taken into consideration.

In a method suggested by the Air Hygiene Foundation the air sample is bubbled through 0.5 per cent potassium hydroxide after which the determination is made by titrating with silver nitrate. [See the foundation's preventive engineering series, bulletin 2, part 8.]

Sulfur Dioxide

Exposures to sulfur dioxide gas are common in the petroleum industry, rubber works, and sulfuric acid manufacturing. Sulfur dioxide is also encountered in bone and glue works, magnesium foundries, and other industries where sulfur compounds are used. It is an extremely irritating gas for which a threshold limit of 10 ppm has been suggested.

For the testing of sulfur dioxide, the American Public Health Association [pp. 80-85, 1935-1936 yearbook, APHA] refers to an iodometric method [see Fieldner, et al.: Journal of Industrial & Engineering Chemistry, 11:519, 1919] by means of which the air sample is passed through a gas wash bottle containing a measured amount of



Hydrogen sulfide detector

standard iodine in potassium iodide-starch solution. The disappearance of the color indicates the end of the test, after which the amount of sulfur dioxide present can be calculated.

The British department of industrial research employs a starch-potassium iodate test paper through which the air sample is drawn by means of a hand pump. The sulfur dioxide reduces the iodate to iodine with the production of a stain the degree of which is compared to known color standards.

Oxides of Nitrogen

This is a group of gases, some of which are extremely toxic. They are produced when nitric acid comes in contact with organic materials and certain metals; during chemical nitration processes and burning of nitrated materials; they are also present in small quantities during electrical discharges in the air. These gases may, therefore, be found in such industries and operations as ammunition works, photographic film manufacturing, nitric acid plants, electroplating (bright dipping), detonation of explosives, electric welding, etc.

During the chemical reactions that accompany the above operations, a mixture of oxides is formed. The hazardous nature of this group, also called "nitrous fumes", is due primarily to the nitrogen dioxide, a reddish brown gas which reacts with water and upon respiration forms nitric acid in the lungs. The result is often pulmonary edema, which frequently proves fatal.

The fact that the respiration of these gases does not produce any immediate discomfort in spite of their toxicity makes them doubly dangerous. A person may be exposed to these fumes and experience only a slight respiratory irritation immediately following the exposure, while the case may develop into a fatal condition by the next day. For example, I know of a case in a nitric acid plant where a man was engaged in filling nitric acid into carboys in a department with a wooden floor. One of the carboys accidentally broke, causing the acid to flow over the wooden floor and producing the brown nitrogen dioxide gas in great volume. The operator not being familiar with the toxicity of this gas and experiencing no immediate physiological warning, remained on the job attempting to clean the floor by mopping up the acid, instead of leaving the work place for fresh air. As a result a considerable portion of this gas was probably inhaled. He became seriously ill a few hours later and died within 48 hr. Cases of men becoming sick while doing electric welding inside tanks or in other confined spaces are often referred to in the literature; many of these cases are undoubtedly due to oxides of nitrogen generated in the electric arc.

While there are several methods known for the quantitative determination of oxides of nitrogen, testing for these air contaminants is not so simple as that for some of the others discussed. Incidentally, in view of the cumbersome procedures involved in testing for these gases, the amount of ventilation required for their control after

blasting in mining and tunnel work is sometimes based on the amount of carbon monoxide present, which can readily be determined. With explosives designed for a low oxygen balance resulting in a relatively high carbon monoxide concentration and correspondingly low volumes of oxides of nitrogen, this is a safe and expedient procedure.

For actual detection of nitrogen dioxide, the method employing starch-potassium iodide test paper is probably the best known. This paper when damp is colored blue in the presence of nitrogen dioxide. The method is nonspecific, however. Other, specific methods for evaluation of nitrogen dioxide, and sensitive at low concentrations are the Griess-Ilosvay and the Bismarck Brown tests. With both methods, the air sample is bubbled through chemical solutions after which the quantitative determinations are made in the laboratory by colorimetric analysis. Although physiological safe limits up to 40 ppm have been proposed for these gases, atmospheres which by odor or color indicate the presence of nitrous fumes should always be viewed with suspicion.

Ammonia

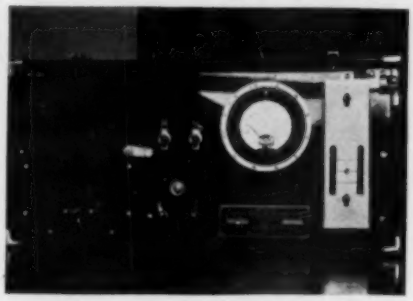
Ammonia is an important raw material throughout the chemical industry. It is a strong respiratory irritant for which safe limits ranging between 50 and 85 ppm have been recommended (Russian investigators, 13-39 ppm; State of Massachusetts, 50 ppm; Flury and Zernik, 85 ppm).

Ammonia vapors can be evaluated directly in the field by bubbling the air sample through a measured volume of 0.1 N hydrochloric acid in water solution using phenolphthalein as an indicator; the appearance of a pink color indicates the end point. From the amount of acid used and the size of the air sample, the concentration of ammonia vapors can be calculated.

Sulfuric acid can also be used with the above method. In another method, recommended by the American Public Health Association, the air sample is collected in sulfuric acid, but the final evaluation is made in the laboratory by standard analytical means.

Phosgen

A discussion of this kind would hardly be complete without a few words about the extremely toxic gas phosgen, for which a maximum safe limit of 1 ppm has been suggested for prolonged exposures. This gas is often generated through decomposition of vapors of chlorinated hydrocarbons such as trichloroethylene and carbon tetrachloride, when in contact with open flames or overheated metal surfaces. Operations involving gas burners,



Hopcalite carbon monoxide indicator

blow torches, electric arcs, etc., should therefore be kept away from degreasing processes. Welding should never be permitted on a tank containing above substances.

For determination of phosgen, the American Public Health Association refers to a method in which air to be sampled is passed through a gas washing bottle containing alcoholic sodium hydroxide, after which the solution is neutralized with nitric acid and titrated with silver nitrate.

The standard method adopted by the British department of industrial research for determination of phosgen consists of drawing the air sample through a test paper coated with diphenylamine and p.dimethylamino-benzaldehyde, by means of a hand pump. When phosgen contacts these chemicals, a yellow or orange stain is produced which is compared to a standard color chart for the evaluation of the amount of phosgen present.

Radon and Thoron

In view of the potency of radon and thoron, with respect to lung pathology, the evaluation and control of these two gases in industrial atmospheres are major problems of occupational hygiene. Industrially, they are found primarily in radium dial painting works of the aviation industry and in the manufacturing of thorium gas mantles, respectively.

Air samples for the determination of radon in industrial plants are usually collected by means of evacuated glass containers. The radon content of any air sample is evaluated by placing it in an ionization chamber connected to a sensitive electrometer whose readings are recorded photographically. The ionization produced is proportional to the amount of radon present in the chamber. The apparatus is calibrated with known quantities of radon obtained from a standard radium solution. Alternatively, alpha-ray pulse counting apparatus may be used in place of the electrometer. Since radon has a half period of 3.8 days, air samples containing radon may be shipped for analysis to a central laboratory from any part of the United States [see R. D. Evans, Review of Scientific Instruments, 6:99-112, 1935; also, S. C. Brown, L. G. Elliott, and R. D. Evans, Review of Scientific Instruments, 13:147-151, 1942].

Thoron has a half period of only 54 sec, and is consequently unsuited for direct analysis; i.e., the sample decays before accurate measurements can be made on it. For this reason a special field sampling apparatus has been devised [see R. D. Evans and C. Goodman, Journal of Industrial Hygiene & Toxicology, 22, 3, pp. 89-99, March, 1940] which collects the long-lived (10.5 hr) decay product of thoron known as thorium B. This substance is a solid and the activities of such samples, taken in thorium gas mantle plants,* are sufficiently great so that accurate measurements can be made several days after taking the sample. The activity of the thorium B depends on the activity of the thoron in the original air, on the length of time which the thorium B collector is operated, and on the interval elapsing between collection and analysis. The thorium B activity is measured with an alpha-ray pulse counter. Calibration is achieved by collecting thorium B from the thoron produced in a closed region, by a known amount of thorium and its equilibrium decay products.

*Evans, R. D.; Nilson, S. J.; Goodman, C.; and Bernz, N. R. Industrial Application of a Method for Determining the Thoron Content of Air. Proceedings of the VIII International Congress on Occupational Diseases and Preventive Medicine, held at Frankfurt a.M., Germany, September 26-30, 1938.

Heating · Piping · Air Conditioning

AMERICAN SOCIETY of HEATING and VENTILATING ENGINEERS

Journal Section

50th Annual Meeting

January 31 - February 1-2, 1944—New York, N. Y.

Alfred J. Offner,
General Chairman

"THE PAST," "The Present," and "The Future" will be effectively portrayed at the 50th Annual Meeting of the Society to be held at the Hotel Pennsylvania, New York, N. Y., January 31, February 1 and 2, 1944.

It was in the summer of 1894 that a small group met to organize the ASHVE and in the report of the deliberations on September 10, it was significant that, "temperature conditions were decidedly uncomfortable, but the meeting was very well attended." At this meeting the objects of the Society were outlined and a Constitution and By-Laws were adopted. A reproduction of the report of the meeting as given in the magazine *Heating and Ventilation* is shown on page 486 and should recall to many members vivid recollections of the founders of the Society.

To properly commemorate the 50th Anniversary of the organization of the Society the Committee on Arrangements of the New York Chapter is developing a special program which will be appropriate for the occasion.

R. H. Carpenter

A three-day session will be held and technical papers of basic importance will be presented. The organization of the Committee on Arrangements has been announced by Alfred J. Offner, General Chairman, as follows:

Honorary Chairmen: Homer Addams, W. H. Carrier, W. H. Driscoll, W. L. Fleisher, and D. D. Kimball.

Vice-Chairmen: R. H. Carpenter, J. C. Fitts, W. E. Heibel, C. S. Koehler, Capt. A. E. Stacey, Jr., and R. A. Wasson, president of New York Chapter, ex-officio.

Chairmen of Special Committees: Alfred Engle, Banquet; W. M. Heebner, Finance; H. S. Wheller, Hospitality; C. S. Pabst, Inspections; Mr. and Mrs. H. J. Ryan, Ladies; R. V. Sawhill, Publicity; E. J. Ritchie, Sessions; A. C. Buensod, Special Events.

A GREAT PAST **A GREATER FUTURE**

J. C. Fitts

C. S. Koehler

Capt. A. E. Stacey, Jr.

R. A. Wasson

THE AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

Report of Meeting held at New York, Sept. 10.

The adjourned meeting for the formation of a society of heating and ventilating engineers which was held at the Broadway Central Hotel, New York, on Sept. 10, under temperature conditions decidedly uncomfortable, was nevertheless very well attended, and it is encouraging to report that the intense interest which was taken in the new movement bids fair to advance the arts and sciences of heating and ventilation, and elevate the work of the heating and ventilating engineer to a position the dignity and importance of which could not possibly be attained in any other manner.

The meeting was called to order at 3 o'clock by the chairman, Mr. Fred I. Smith, of New York, who requested Mr. Harding to take the chair for a few minutes. On assuming the chair Mr. Harding announced that Mr. Smith would address the meeting, defining the objects, advantages, and policy of the proposed organization. The subject matter of Mr. Smith's extempore address is as follows:

E. F. Bates, Pres.

GENTLEMEN: The Committee has put me down for what they call an address, but I am not making addresses when the temperature is anything like this, and they are all looking for what we may call "a leaf-pipe cooch"—to get something that is different from others and take a patent on it, and try to convince the public that nothing else in the world will do the work. If we permit this thing to be done, it will surely work to the detriment of the profession. It is only by the united efforts of the members of the society that we may expect to attain the improvement for which we are looking. There is no reason in the world why the society council, if properly worked, will not in us in raising a high standard of work, and regulate the price we ought to get for our work. What we want is a long, strong pull together, and that is exactly what I meant when I spoke of good fellowship.

We need more "the maintenance of a high professional standard among heating and ventilating engineers." This does not mean cut-throat prices. Of course, to stay we are working; such up as we are of a society of engineers, our members will be subdivided into many different engineers. There will be the consulting engineer, who is paid for his professional services, and the constructing engineer, who receives pay for his professional services and a profit on all the goods he sells. We find in the field to-day several classes of incompetents classing ready to be employed by the latter capacity. Should it fail to be well for all who propose entering this field to prepare themselves especially for it? We should surely have a method of preparation and qualification of such persons, and at tendance at such a school for proper qualification for other means of entry to the only means by which a man could enter upon his duties as a heating and ventilating engineer. If this method be adopted, and others, would tend to a higher professional standard.

To establish a clearly defined minimum standard of heating and ventilating for all classes of buildings. This is a very important matter for our consideration. The idea in this Massachusetts started out with a compulsory ventilation law. Most of the laws that have been passed since specify "the Massachusetts standard of ventilation." In their plans and appears that that is absolute. As a matter of fact, there is no standard there, and whether or not there are unsatisfactory conditions is entirely left to the judgment of the inspector. They have never formulated any kind of standard. They have had a standard, however, filed in schools the standard should be 30 cubic feet per pupil per minute, but further than that they have not gone.

The lack of a definite standard for ventilation in public buildings has very often been the cause of considerable inconvenience. A man may do good work and give entire satisfaction in one district, and on going into another district he will find that he is dealing with a different inspector and an entirely different set of requirements. You will see how much it is for a man to do first-class work in one place and then come up to the requirements to another under a different inspector, who, while following out the same standard, as he understands it, has a different idea as to how it should be done. Now, there won't be difficulties as these, every member of our society should do his best, to have a universal standard adopted which shall be definitely known and accepted in each

E. M. Mackay, First Vice President.

city, and every one may be on the same footing. You can readily see the evil of having competitors go out and say all to bid to work which may be accepted by one man on his customer, and the manufacturing engineer, who receives pay for his professional services and a profit on all the goods he sells. We find in the field to-day several classes of incompetents classing ready to be employed by the latter capacity. Should it fail to be well for all who propose entering this field to prepare themselves especially for it? We should surely have a method of preparation and qualification of such persons, and attendance at such a school for proper qualification for other means of entry to the only means by which a man could enter upon his duties as a heating and ventilating engineer. If this method be adopted, and others, would tend to a higher professional standard.

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W. P. Wells, Second Vice President.

city, and every one may be on the same footing. You can readily see the evil of having competitors go out and say all to bid to work which may be accepted by one man on his

condemned by another under the same requirements, here answering that could be, and the necessity that standards should be uniform.

The movement is under way to have such a law passed here, and if passed it should be brought into every field where a conflicting service exists. Be required, it is desirable, also, that there should be a society to see that it is done in such a way that everybody has equally fair chance, and that the inspectors are so limited in their powers that they can judge only as to results.

Now, having adopted such a standard,

Chas. Warren Hunt, Vice President.

we will want to have all our public buildings ventilated in accordance therewith. Nothing has advanced the work of ventilation to the last three years as regards the rule down in Massachusetts. While architects are all well informed as to their several duties, there are not well informed as to heating and ventilation, and this fact has been brought out more prominently by the recent passage of the rule in regard to Massachusetts than by any other means. The heating and ventilating of a building should be dealt with in the basis of a specific, not so much as should the steam and electric equipment.

To encourage legislation favorable to the improvement of the arts of heating and ventilation, and to oppose legislation inimical to the interests of the profession. I think I have touched upon that paragraph, and it will not be necessary to add much to it.

The compulsory law in Massachusetts has created a great demand for the services of men skilled in this profession. Even here in New York the demand has not existed to such an extent, but legislation would bring the matter more prominently to the attention of architects and builders.

To the reading, discussion, and publication of professional papers, and the interchange of knowledge and experience among its members. I think it is not necessary to go into that any further at all.

Now, then, there is one other question which comes up in connection with this, while judging of the matter of policy, and which I think the society ought to establish. There are architects who think some very highly of heating and ventilation, and there are others who have not taken the trouble to go into the matter very thoroughly. We have not been talked to about it, and there are many civil engineers who are interested in heating and ventilation. Why not bring them into with us in this society? Any man with a technical training and practical experience might be benefited into the field, with a good example to all. There are many who already belong to engineering societies. The Society of Mechanical Engineers is large and strong, but ventilation has scarcely been touched upon by that society, and the interests of this conference have not been given the attention and recognition due to them. If is for that reason we are now forming the Society of Heating and Ventilating Engineers.

The remaining the chair Mr. Smith called for the reading of the names of those who had subscribed themselves an charter members of the new society, whereupon Mr. Hall, the temporary clerk, read the following list of signed members:

J. H. Hall, Secretary.

Consulting Engineer, C. E. '12 Liberty street, New York.
Architect, Boston, Mass.
Architect, Boston, Mass.
Architect, Boston, Mass

Discoloration Methods of Rating Air Filters

By Frank B. Rowley* and Richard C. Jordan**
Minneapolis, Minn.

This paper is the result of research sponsored by the American Society of Heating and Ventilating Engineers in cooperation with the Engineering Experiment Station, University of Minnesota.

SUMMARY—In addition to a review of the principal photometric methods used at present in rating air filters, the authors present a new method of determining the true discoloration efficiency of air filters. The theory of discoloration is analyzed. The term *value* is introduced in order to take into consideration the psychological and physiological reactions of the human eye in interpreting discoloration. Without making a specific recommendation toward adopting any one method of rating discoloration efficiency the authors present their research as a contribution to the collective knowledge on the subject.

ONE OF the primary uses to which air filtration has been placed in recent years is for the removal of those air borne dusts which cause discoloration or soiling of decorated surfaces and merchandise. In order that filters may be rated properly as to their ability to reduce such discoloration, it is first necessary to devise satisfactory laboratory test apparatus for the study of efficiencies based upon this principle. However, as with all other problems involving the measurement of air filter efficiencies, the difficulties are legion, to a great extent, because of the lack of strict definition as to the exact property which it is desired to measure. The purposes of the present investigations are:

1. To review the present methods of determining air filter efficiencies by photometric methods.
2. To analyze the phenomenon of discoloration.
3. To develop apparatus for determining the efficiency of air filters based upon a true measure of discoloration.
4. To present comparative test data showing the efficiencies of standard filters rated by different discoloration methods.

Review of Present Photometric Methods of Rating Air Filters

One of the earlier methods used for rating air filters by photoelectric means was reported by Nutting[1] and consisted essentially in determining the *weight* efficiency of filters, that is, the percentage of the weight of dust removed by a filter. Calibration curves were prepared showing the relationship between the weight of the test dust fed to the filter and the current generated by a photoelectric cell. The dust fed to the filter was collected on a porous filter paper target which was subjected to a light beam on one side and a photometer on the other. With this apparatus, the photoelectric responses for definite weights of dust passing the filter were determined, and it was then possible to calculate the filter efficiency on a weight basis.

The first method of determining filter-efficiency on a true discoloration basis was developed by the Bureau of Standards and reported by Dill.[2] This method consisted essentially in removing air samples simultaneously from upstream and downstream of a filter, passing these samples through porous filter papers to remove the dust, and then subjecting these papers to a light beam and photometer to determine the concentrations of the dust deposits. In rating filters by this or allied methods, the efficiency may be determined by application of Equation (1):

$$\text{Efficiency} = 1 - \frac{C_1}{C_2} \quad \ldots\ldots (1)$$

Where C_1 = downstream dust concentration
C_2 = upstream dust concentration

The density of dust, D, on the filter paper will vary with the area, the rate of sampling, the concentration, and the time of sampling as in Equation (2):

$$D = \frac{QtC}{A} \quad \ldots\ldots (2)$$

Where Q = volume of air sampled, cubic feet per minute
t = time of sampling, minutes
A = area of dust deposit, square inches
C = concentration of dust in air stream
D = density of dust deposit on filter paper

If Equation (2) is solved for C, then,

$$C = \frac{DA}{Qt} \quad \ldots\ldots (3)$$

This expression may be then substituted in the efficiency equation giving:

$$\text{Efficiency} = 1 - \frac{D_1 A_1 Q_2 t_2}{D_2 A_2 Q_1 t_1} \quad \ldots (4)$$

In practice, the application of this relationship requires that three of the four variables, A, D, Q, and t, be kept constant and the other varied. As it is difficult to measure D in absolute units, but is comparatively easy to determine when D_1 and D_2 are equal, this variable is usually adjusted so that D_1 and D_2 cancel.

In the test apparatus and procedure devised and reported by Dill all tests were made by letting

$$D_1 = D_2$$
$$t_1 = t_2$$
$$Q_1 = Q_2$$

and thus,

$$\text{Efficiency} = 1 - \frac{A_1}{A_2} \quad \ldots\ldots (5)$$

*Director, Engineering Experiment Station, University of Minnesota. Member of ASHVE.
**Assistant Director, Engineering Experiment Station, University of Minnesota. Member of ASHVE.
[1] An Alternate Method of Comparing the Dust Arrestance of Air Cleaning Devices, by Arthur Nutting. (ASHVE Transactions, Vol. 43, 1937.)
[2] A Test Method for Air Filters, by R. S. Dill. (ASHVE Transactions, Vol. 44, 1938.)

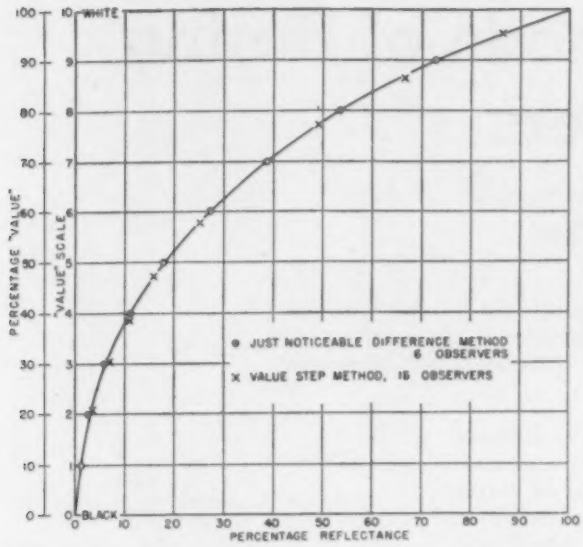

Fig. 1 — Relationship between physical (reflectance) and psychological (value) interpretations of the lightness of a surface[4]

Thus, with this method, the size of the filter papers is varied by providing different apertures corresponding to the different efficiencies. In order to determine when the densities of dust on the two filter papers are equal, these papers are subjected to a light beam on one side and a photometer on the other. It is then considered that the dust densities are the same when the amounts of light transmitted through the filter papers and measured by the photometer are equal.

A modification of this method was devised by Rowley and Jordan[3] in which,

$$D_1 = D_2$$
$$t_1 = t_2$$
$$A_1 = A_2$$

and thus,

$$\text{Efficiency} = 1 - \frac{Q_2}{Q_1} \quad \ldots\ldots (6)$$

In this modification, the volumes of air sampled on the two sides of the filter were varied until the resulting dust spot densities on the porous filter papers were equal. In addition, a further modification was adopted for determining the relative discoloration of the filter papers by subjecting them to a beam of light and determining by means of a photometer the amount of light reflected. Both the incident and the reflected light beams were at angles of 45 deg to the filter paper surface and 90 deg to each other. Reflected light measurements were used in place of transmitted light measurements because this more nearly simulates the mechanism of the human eye in evaluating discoloration.

All three of the methods here reviewed for rating the efficiency of air filters by photometric means result in different efficiencies when applied to identical filters. The reasons for these filter rating discrepancies are fundamental as each method measures a somewhat different property of the filter and there has, as yet, been no attempt at strict definition as to the exact measurement desired. The desirability appears evident, therefore, for an analysis of the phenomenon of discoloration and the methods by which such discoloration can best be determined.

Theory of Discoloration

Soiling or discoloration is a surface phenomenon dependent for its detection upon a source of incident light and its subsequent diffuse reflection. The brightness and wave length of the reflected light depend upon the color and nature of the surface. The degree to which a soiled area is evident is dependent to a great extent upon the contrast between the soiled area and the surrounding unsoiled areas. If the soiling is even, it may not be readily recognizable as such even though the actual degree of soiling may be greater than in another case of similar soiling made more evident by contrast with surrounding undiscolored surfaces.

The discoloration of surfaces can take place by several other means than by soiling brought about by dust deposits. For example, discoloration by fading as a result of weathering or exposure to sunlight is common. However, as such means of discoloration are not allied to the present problem of air filtration, all references to discoloration in this article will infer discoloration by dust only.

In studying the problems involved in the measurement of discoloration, it is necessary to introduce several terms which are

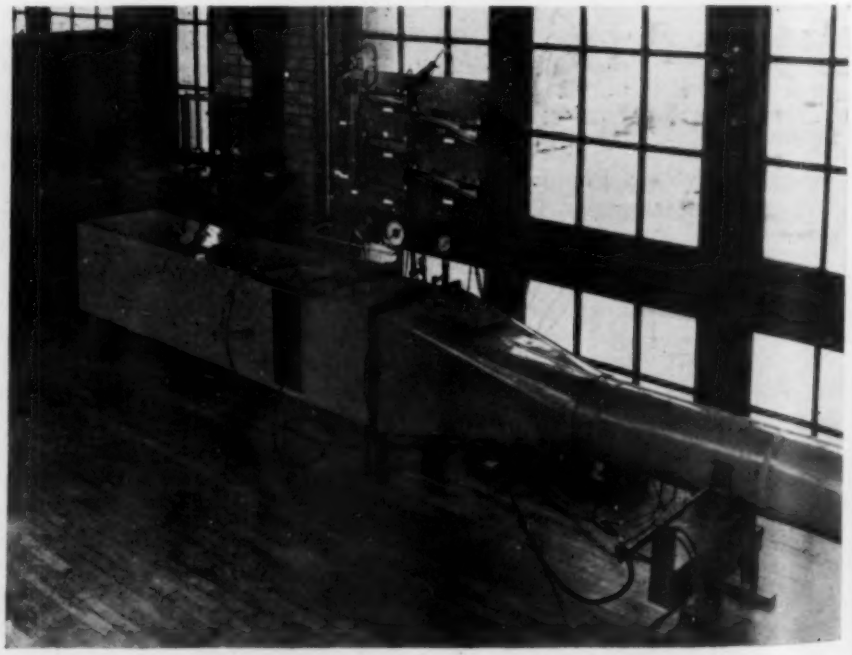

Fig. 2—Assembled view of test apparatus

[3]ASHVE Research Report No. 1169—A Comparison of the Weight Particle Count and Discoloration Method of Testing Air Filters, by Frank B. Rowley and Richard C. Jordan. (ASHVE Transactions, Vol. 47, 1941.)

frequently used ambiguously. However, these terms have definite meanings in the field of photometry, and those meanings will be adopted for present purposes:

Lightness (reflectance) is the ability of a surface to reflect light diffusely. Lightness is frequently expressed as percentage reflection or reflectance with reference to a standard surface assumed to reflect diffusely 100 per cent of incident light. A pure magnesium oxide surface is commonly used for reference because of its exceedingly high reflective characteristics. However, for strictly comparative purposes, any light colored surface may be used.

Brightness is the actual amount of light reflected from a surface; thus, the brightness of reflected light is dependent not only upon the nature of the surface but also upon the intensity of the incident light beam. Therefore, a surface of high lightness will possess zero brightness when no light beam is incident. Brightness is commonly expressed in foot candles.

Value is the psychological and physiological counterpart of lightness. There are no common units of value, but they usually increase numerically from black to white and must be chosen so as to be representative of equal change increments in appearance. Fig. 1 presents the value scale determined by Munsell, Sloan, and Godlove.[4] This figure shows the relationship between value and percentage reflectance as determined by using the *just noticeable difference* and the *value step* methods.

In analyzing Fig. 1, it is interesting to note that in passing from black to white on the value scale, the initial psychological changes are much greater than the initial physical or percentage reflectance changes, and that the final psychological changes are much less numerically than the final physical changes. Applying this to surface discoloration or soiling, the initial discoloration of a light surface by a dark dust will not be as evident as an equivalent initial discoloration of a dark surface by a light colored dust. In this respect it should also be noted that, although we normally think of soiling in terms of the discoloration of a light surface by means of a dark dust, this is not necessarily so. A dark colored surface may be just as readily soiled by a light colored dust and, in fact, such soiling is more readily discernible by the human eye. However, as most dusts are not truly light in color, such discoloration of dark surfaces is not so commonly experienced.

The degree of discoloration of a surface may be measured either by visual or photoelectric means. Visual comparisons while simple are inaccurate because they introduce the human element. On the other hand, trained observers are not required if photoelectric means of reflectance measurement are introduced and furthermore, the sensitivity of the human eye may be reproduced at different wave lengths by the application of a properly designed light filter. For these reasons the several methods of evaluating the discoloration efficiency of air filters developed during the past few years have, practically without exception, used photoelectric means for measurement of light.

The most direct approach to the measurement of air filter efficiencies by discoloration methods is to actually discolor either light or dark surfaces by means of a contrastingly colored dust fed into the air. Thus, the discoloration of white surfaces may be made by black or brown dusts and the discoloration of black surfaces by white or gray dusts. The problem may be further complicated by the introduction of intermediately colored surfaces discolored by contrasting dusts. In such cases, however, it would be possible to have a visual discoloration as evidenced by actual differences in color composition, and yet have the same percentage reflectance of light from both surfaces. Such an analysis of discoloration would necessitate the introduction of a *whiteness* concept involving analysis of the spectrum composition of the reflected light. In most cases such a procedure would needlessly complicate the efficiency determinations and be of little additional value.

[4]Neutral Value Scales I. Munsell Neutral Value Scale, by A. E. O. Munsell, L. L. Sloan, and I. H. Godlove. (*Journal of the Optical Society of America*, Vol. 23, p. 394, Nov. 1933.)

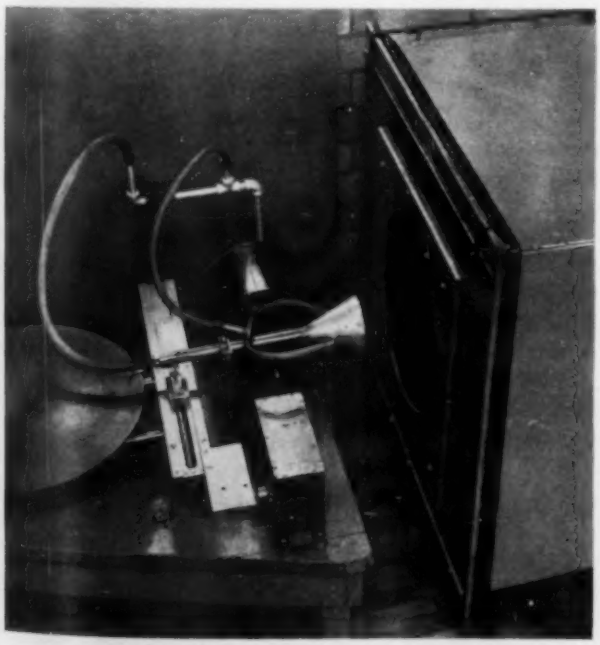

Fig. 3—View of modified dust feeder

Fig. 4—Photometer for measurement of discoloration

Design of Apparatus for Measuring Discoloration Efficiencies

In order to approach as closely as possible a true measurement of the discoloration efficiency of air filters and also to permit modifications of these efficiencies based upon the physiological and psychological reactions of the human eye to discoloration, some changes were made in the apparatus and procedure formerly used at the University of Minnesota for rating air filters.[5] The test duct used for introducing dust to the filter and for measuring the air volumes and the static differential across the filter was identical with that formerly used and is shown in Fig. 2. The dust feeder shown in Fig. 3 was modified in order that small amounts of dust might be accurately weighed and fed uniformly into the air stream. An aluminum channel 6 in. x ½ in. x ½ in. is used to hold the dust. This channel is moved at a uniform velocity past a pickup tube having an inlet the same width as the channel. This pickup tube is connected to the low pressure section of a small Venturi tube through which compressed air is passed. The velocity of the entering air picks the ribbon of dust from the channel and carries it through the tube to a distributing nozzle at the entrance of the filter test apparatus. This apparatus is essentially the same as that previously used for making weight efficiency determinations of air filters[6] with the exception that in the former case the dust was picked up from a flat revolving disk.

The sampling tube used for drawing the air-dust sample from the duct for purposes of discoloring the filter papers is identical with that previously used in the University of Minnesota photometric efficiency tests.[7] However, in this case, instead of using two sampling tubes, one placed upstream and one downstream of the filter, a single sampling tube located at the bell orifice is used. This sampling tube is shown at the right of Fig. 2. The dust samples are drawn from the test duct through the sampling tube by means of a suction pump, and the volumes of the samples measured by means of a calibrated flat plate orifice located in the sampling tube.

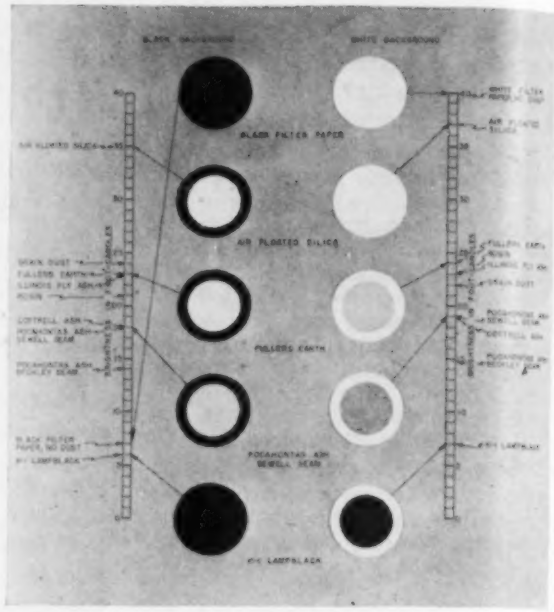

Fig. 5—Maximum discoloration of black and white filter papers by various test dusts

In order to measure the discoloration of the filter papers by means of diffusely reflected light, the apparatus shown in Fig. 4 was used. This consists of a hollow cube 6 in. x 6 in. x 6 in. coated on the inside with several layers of a magnesium oxide paint. On one side of the cube is a hole of 1 in. diameter through which a parallel beam of light is allowed to pass. Directly opposite this opening is another of 1¼ in. diameter against which the filter paper to be measured is placed. On the third wall of the cube and at right angles to the beam of light passing through the cube, a third opening of 1¾ in. diameter is located. A photoelectric cell is placed at this opening so that any light reflected within the cube from the filter paper will affect the cell. The photronic cell used is equipped with a filter so that its sensitivity to different light wave lengths is approximately the same as that of the human eye. This photoelectric cell is connected to a photometer which enables the measurement of the reflected light in foot candles.

Development of Test Procedure

With any one specific type of test dust used in conjunction with any one specific color of background filter paper, it is first necessary to determine the amount of dust to be fed before maximum discoloration is reached. In the present tests two colors of background were used: one, the normal white uncolored filter papers, and the other, similar filter papers dyed black by means of a jet black ink. Tests to determine the maximum discoloration against such backgrounds were made with the following dusts: air-floated silica (200 mesh), Fuller's earth (200 mesh), grain dust (200 mesh), Illinois fly-ash (200 mesh), powdered rosin (100 mesh), Cottrell ash (200 mesh), Pocahontas ash (two different samples taken from different seams—200 mesh), and lampblack (100 mesh).

In making these maximum discoloration determinations, the dusts were fed into the test duct without any filter in place, and the samples drawn out through the sampling tube and deposited upon the filter papers. The actual discolorations of these papers were determined by measuring the foot-candles of diffusely reflected light using the apparatus previously described. All discoloration readings were, of course, relative, as they depended not only upon the intensity of the light reflected from their surfaces, but also upon the design of the photometer. In all cases, the apparatus was adjusted so that when light was reflected from a white, blank filter paper, the brightness of the diffusely reflected light was 40 foot-candles. When the black, blank filter paper was substituted for the white one, the brightness reading was 7 foot-candles. This

[5] Loc. Cit. Note 3.

[6] ASHVE Research Report No. 1094—Air Filter Performance As Affected by Kind of Dust, Rate of Dust Feed, and Air Velocity Through Filter, by F. B. Rowley and R. C. Jordan. (ASHVE Transactions, Vol. 44, 1938.)

[7] Loc. Cit. Note 3.

reading was not zero for two reasons: first, all of the light incident upon the black filter paper was not absorbed, a small percentage of it being reflected diffusely in the photometer cube; and second, some stray rays from the light source were incident upon the walls of the reflecting cube adjacent to the location of the black filter paper. The results of these maximum discoloration tests are shown photographically in Fig. 5. It should be kept in mind that no black and white photograph is capable of accurate reproductions of the visual appearance of these papers, with the possible exceptions of the discolorations obtained by means of air-floated silica and lampblack. With the other dusts there was a considerable range in color not possible to reproduce.

Theoretically, the maximum discoloration using any one type of test dust should be the same regardless of the color of the background. Actually, however, the maximum discoloration was limited to a certain extent by the ability of the dust to cling to the background surface. In most cases, it was found that the dust deposits would tend to flake off the surface of the filter paper before a deposit sufficiently thick to obscure completely the color of the background could be made. It is for this reason that there are discrepancies between the maximum discolorations for a specific type of dust when deposited against both a black and a white background. For example, the maximum discoloration of air-floated silica deposited on a black background proved to be 35 foot-candles, whereas the same dust deposited against a white background resulted in a reading of 37 foot-candles.

These preliminary tests indicated the weights of dust which must be fed to the air stream to result in maximum discoloration of the filter papers when no air filters were located in the test apparatus. They also indicated which test dusts used in conjunction with either a black or a white background would be most practical for filter discoloration efficiency tests. For example, it would be obviously impractical to use lampblack in conjunction with a black background as the diffusely reflected light is approximately the same with or without the lampblack dust deposit. On the other hand, there is a discoloration range of from 40 foot-candles to 7 foot-candles or a spread of 33 foot-candles between lampblack deposits on white filter paper and the plain white background paper itself. It is evident that the greatest contrast between an undiscolored background and a discolored background is desirable from the standpoint of increasing the sensitivity of the efficiency tests. From this standpoint the two most desirable combinations investigated were lampblack used in conjunction with a white background and air-floated silica used in conjunction with a black background.

In establishing an efficiency versus light reflectance scale, 100 per cent efficiency was taken as corresponding to the light reflectance from the blank filter paper with no dust deposits. A definite weight of dust was then chosen to be fed to the filter under test, this weight being somewhat less than that causing maximum discoloration of the filter paper and also less than that giving heavy enough deposits on the filter paper to cause flaking. When this weight of dust was fed into the test duct with no filter in place, the light reflectance corresponding to the resulting dust deposit on the paper was taken as that for 0 per cent efficiency. These points of 100 per cent and 0 per cent efficiency were chosen to correspond to the conditions in which none of the dust and all of the dust fed to the filter passed through the test apparatus. It was then assumed that the relationship

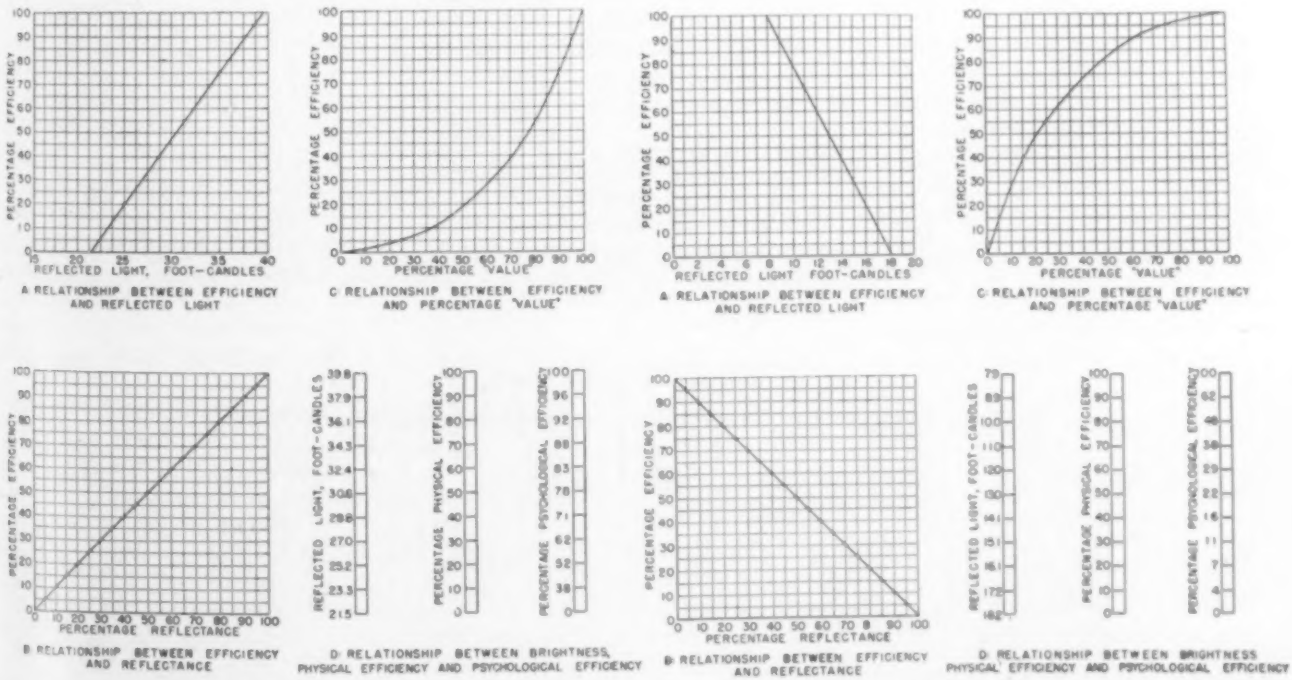
PERCENTAGE EFFICIENCY
REFLECTED LIGHT, FOOT-CANDLES
A RELATIONSHIP BETWEEN EFFICIENCY AND REFLECTED LIGHT
PERCENTAGE "VALUE"
C RELATIONSHIP BETWEEN EFFICIENCY AND PERCENTAGE "VALUE"
PERCENTAGE REFLECTANCE
B RELATIONSHIP BETWEEN EFFICIENCY AND REFLECTANCE
REFLECTED LIGHT, FOOT-CANDLES
PERCENTAGE PHYSICAL EFFICIENCY
PERCENTAGE PSYCHOLOGICAL EFFICIENCY
D RELATIONSHIP BETWEEN BRIGHTNESS, PHYSICAL EFFICIENCY AND PSYCHOLOGICAL EFFICIENCY

Fig. 6 — Relationships between brightness, physical discoloration efficiency, and psychological discoloration efficiency for lampblack against white background

PERCENTAGE EFFICIENCY
REFLECTED LIGHT FOOT-CANDLES
A RELATIONSHIP BETWEEN EFFICIENCY AND REFLECTED LIGHT
PERCENTAGE "VALUE"
C RELATIONSHIP BETWEEN EFFICIENCY AND PERCENTAGE "VALUE"
PERCENTAGE REFLECTANCE
B RELATIONSHIP BETWEEN EFFICIENCY AND REFLECTANCE
REFLECTED LIGHT, FOOT-CANDLES
PERCENTAGE PHYSICAL EFFICIENCY
PERCENTAGE PSYCHOLOGICAL EFFICIENCY
D RELATIONSHIP BETWEEN BRIGHTNESS, PHYSICAL EFFICIENCY AND PSYCHOLOGICAL EFFICIENCY

Fig. 7 — Relationships between brightness, physical discoloration efficiency, and psychological discoloration efficiency for powdered silica against black background

between filter efficiency and diffusely reflected light was linear between these two limiting points. In this way the filter efficiency was made directly dependent upon the degree of the resulting discoloration as determined photometrically. Thus, the efficiency is a function of the degree of discoloration alone with no definite relationship between filter efficiency and weight of dust fed or filter efficiency and dust particle count.

Figs. 6 and 7 show the evolution of the relationships between brightness of diffusely reflected light, physical discoloration efficiency, and psychological discoloration efficiency. Fig. 6 is for a dark dust, lampblack, on a white filter paper background. In these figures *Curve A* shows the relationship between brightness of reflected light and filter efficiency as determined photometrically. *Curve B* shows the relationship between percentage reflectance and filter efficiency. In the case of lampblack on white filter paper, 0 per cent reflectance was taken to correspond to the foot-candles of reflected light at 0 per cent efficiency and 100 per cent reflectance to correspond to the foot-candles of reflected light at 100 per cent efficiency. In the case of the light dust against a black background, 100 per cent reflectance corresponded to 0 per cent efficiency, and 0 per cent reflectance to 100 per cent efficiency. *Curve C* of both figures shows the relationship between percentage physical efficiency as determined by the photometer and percentage psychological efficiency corresponding to the reactions of the human eye. These curves were taken from the data presented in *Curve B* and the relationship between percentage *value* and percentage reflectance shown in Fig. 1. In this manner the discoloration efficiency is presented in terms of a scale based upon the visual conception of discoloration. It is related in no direct way to the physical quantity of dust which has passed through the filter but is based entirely upon the human eye's conception of the potential discoloring properties of the air-dust mixtures passing the filter. From an inspection of *Curve C*, it is evident that the human eye is less sensitive to slight discolorations of light surfaces by means of dark dusts than are photometric measuring devices. On the other hand, the human eye is more sensitive to slight discolorations of dark surfaces by means of light dusts than are photometric measuring devices.

Curves D of Figs. 6 and 7 present by means of bar diagrams a direct comparison between the brightness of the reflected light in foot-candles, the percentage physical efficiency, and the percentage psychological efficiency or *value*. These bar diagrams present in another form a direct comparison of relationships shown in *Curves A, B* and *C*.

Air Filters

In order to determine the relative efficiencies of typical filters when rated by the physical and psychological discoloration methods, four filters were chosen for test. These filters were identical with those used in previous tests,[5] and briefly may be described as follows:

Filter A — A permanent type of cleanable oil filter 4 in. thick with 24 layers of expanded metal and wire screen graded from coarse mesh at entrance to fine mesh at leaving side.

Filter B—A viscous coated throw-away type filter two inches thick, the fibrous media graded in fiber size, density, and oiling from entering to leaving side.

Filter C—A cellular type filter two inches thick built in two sections, each with the axis of cells set at 45 deg to the center line of duct and at 90 deg to each other. The cells on the entering side were of larger dimensions than those on the leaving side of the filter.

Filter D—A filter of cotton media of coarse material on the entering side and glazed on the leaving side. The filter media were accordion-pleated in frame to give an area of approximately twelve times the cross sectional area of air stream.

Discoloration Efficiency Test Results

Each of the four filters described was tested to determine the physical discoloration efficiency and the psychological discoloration efficiency using six different combinations of black or white background with different colors of test dust. Three of these combinations consisted of white filter papers with lampblack, Pocahontas ash, and powdered rosin as test dusts, and the other three with black filter papers using silica, Pocahontas ash, and powdered rosin as test dusts. The Pocahontas ash and rosin were both intermediately colored dusts and, therefore, were applicable to either a black or a white background. The air-floated silica was very white and, therefore, could only be used against a black background, and the lampblack could only be used against a white background. Strictly speaking, the relationship of Fig. 1 used in deriving the psychological discoloration efficiencies is applicable only to the cases of the black dust on a white background or the white dust on a black background. Wide application of colored dusts with this method of testing would require the establishing of an accurate reflectance versus *value* curve for the particular type of dust used.

The results of these tests, made

[5]Loc. Cit. Note 6.

Table 1—Comparison of Physical and Psychological Discoloration Efficiencies

Type of Dust Feed	Color Background Paper	Wt. Dust Fed, Grams	Filter A		Filter B		Filter C		Filter D	
			Physical Discoloration Efficiency	Psychological Discoloration Efficiency	Physical Discoloration Efficiency	Psychological Discoloration Efficiency	Physical Discoloration Efficiency	Psychological Discoloration Efficiency	Physical Discoloration Efficiency	Psychological Discoloration Efficiency
Lampblack	White	1.0	34	66	32	64	7	30	52	78
Air Floated Silica	Black	10.0	47	19	58	28	23	8	57	27
Pocahontas	White	6.0	37	68	26	58	28	60	64	85
Pocahontas	Black	8.0	70	38	74	42	45	18	80	48
Rosin	White	8.0	..	..	30	62	41	72	32	64
Rosin	Black	8.0	67	34	73	41	34	13	61	30

at a filter air face velocity of 300 fpm, are presented in Table 1. The first column of this table records the color of the background filter paper, the second column the type of dust fed, and the third column the weight of dust fed. The dust weights were somewhat under those which, when tested with a filter of 0 per cent efficiency, would result in a dust deposit susceptible to flaking from the surface. The next eight columns of the table present the test results for filters A, B, C, and D. It was found impossible to determine a valid rating for filter A using rosin dust against a white background, as it was found that the color of the dust changed in passing through the filter which resulted in fictitious negative efficiencies. This apparently was caused by a reaction between the rosin dust and the filter oil which resulted in a blacker shade of dust than the original entering the filter. This may likewise have had some effect upon the other efficiency ratings reported for filter A when using the same dust with a black background, and possibly even for the other three filters rated. However, as there was no evidence to substantiate this possibility, the remaining results have been recorded for comparative purposes.

As was to be expected, in all cases where dark dusts were used against white background filter papers, the psychological discoloration efficiencies were considerably higher than the physical discoloration efficiencies. As may be seen by an inspection of the relationships shown in Fig. 6, the increase in psychological over physical efficiency is the greatest when the physical discoloration efficiency is the lowest and the least when the physical discoloration efficiency is the highest. The greatest and the smallest percentage changes in efficiency in translating from the physical to the psychological basis were noted in these tests for lampblack tested on filter C with a white background paper in which the efficiency increased from 7 per cent to 30 per cent, and for Pocahontas ash tested on filter D with a white background paper in which the efficiency increased from 64 per cent to 85 per cent. In the first case, the increase in efficiency was 329 per cent and in the second case, 33 per cent.

As indicated by the relationships shown in Fig. 7, the psychological efficiency will always be lower than the physical efficiency when black background filter papers are used in conjunction with light colored test dusts. In these cases, the smallest percentage changes are found on translating physical discoloration efficiencies to psychological discoloration efficiencies when the initial physical discoloration efficiencies are highest. The maximum percentage changes are found when the initial physical discoloration efficiencies are the lowest. However, the range in percentage changes for the different filters tested was not as great in the case of the black background filter papers as in the case of the light background filter papers, the maximum being 65 per cent and the minimum 40 per cent.

Table 2 presents a comparison of the efficiency tests for filters A, B, C, and D rated by eight different methods using Pocahontas ash and five different methods using lampblack. The weight or crucible method referred to is essentially that described in the ASHVE Code.[9] In determining efficiencies by this method, a known weight of dust is injected into the air upstream of the filter, and samples of the air and dust are removed downstream of the filter and weighed. The weights of dusts entering and leaving the filter are used to determine the efficiency. The particle count method referred to consists essentially of removing air samples simultaneously upstream and downstream of the filter and determining by microscopic examination the number of particles per unit volume of air. The filter efficiency is based upon the relative particle count concentrations upstream and downstream of the filter.[10] The optical density method of rating air filters referred to in Table 2 is that previously described in this paper in which the filter efficiency determinations are made by the application of Equations (1) and (6). For purpose of comparison, tests have been made by this method both with photometric measurements made using transmitted light and using reflected light. The physical and psychological discoloration efficiencies referred to in Table 2 are those made by the filter rating methods presented in this paper and compared in Table 1.

These efficiency determinations summarized in Table 2 for the two types of test dusts and the four different filters indicate clearly the extremely wide variations in test results which may be obtained using a single filter with a single type of test dust. In all cases with any one filter using a single type

[9] ASHVE Standard Code for Testing and Rating Air Cleaning Devices Used in General Ventilation Work. (ASHVE Transactions, Vol. 39, 1933.)

[10] Loc. Cit. Note 3.

Table 2—Comparison of Efficiencies Determined on Four Filters by Eight Different Test Methods

Method of Determining Efficiency	Efficiency Filter A		Efficiency Filter B		Efficiency Filter C		Efficiency Filter D	
	Pocahontas Ash	Lampblack	Pocahontas Ash	Lampblack	Pocahontas Ash	Lampblack	Pocahontas Ash	Lampblack
Weight	93	45	96	63	85	33	90	84
Particle Count	..	..	33	..	22	..	40	..
Optical Density, transmitted light	25	10	36	33	18	10	48	71
Optical Density, reflected Light	51	37	48	54	30	9	67	71
Physical Discoloration, white background	37	34	26	32	28	7	64	52
Psychological Discoloration, white background	68	66	59	64	61	30	85	78
Physical Discoloration, black background	70	..	74	..	45	..	80	..
Psychological Discoloration, black background	36	..	40	..	19	..	46	..

of test dust, the weight efficiencies are the highest, and with the exception of filter C, the particle count efficiencies are the lowest. Although the six remaining methods of determining filter efficiency are all some form of discoloration test method, the divergence in results on any one filter with a single test dust is great. For example, the results on filter C with Pocahontas ash range from 18 per cent to 61 per cent, and those for filter A with Pocahontas ash range from 25 per cent to 70 per cent. Such divergent results are principally the result of a lack of strict definition as to the property to be measured. Strictly speaking, the psychological discoloration efficiencies are probably the closest approach to the inherent reduction in discoloration available in a filter as judged by the human eye. Even with the psychological discoloration efficiencies on any one specific filter using a specific test dust, there is a range of results available dependent upon the color of the background upon which this dust is deposited. However, it would appear more logical to utilize a white background for use with a black or nearly black dust as this appears to simulate the commonest source of discoloration.

Summary

In this paper the principal photometric methods used at the present time in rating air filters have been reviewed. It has been shown that no two of these methods result in the same air filter efficiency ratings when applied to identical filters using the same type of test dust, principally because each method measured a somewhat different property of the filter.

In an attempt to arrive at a rational basis founded solely upon the ability of the filter to reduce the potential discoloring properties of an air-dust mixture, the theory of discoloration has been analyzed. It has been shown that discoloration as measured by photometric means alone is not sufficient to fully define discoloration as judged by the human eye. For this reason the term *value* has been introduced in order to take into consideration the psychological and physiological reactions of the human eye in interpreting discoloration.

A new method of determining the true discoloration efficiency of air filters has been developed. This method is based upon the assumption that a filter of 100 per cent efficiency will filter the air to a point where samples of the air-dust mixture passing the filter and drawn through porous filter papers will cause no discoloration, and the air-dust samples from a filter of 0 per cent efficiency will cause discoloration equivalent to that which would be obtained were no filter present. All intermediate stages of discoloration are assumed to be in direct linear relationship with filter efficiency. Thus, by this method the degree of discoloration of filter papers is taken as the sole criterion of efficiency, and there is no direct relationship between this discoloration efficiency and the removal of dust as measured on a weight or particle count basis. These physical discoloration efficiencies have been translated by a *value* — reflectance relationship into what has been termed a *psychological discoloration efficiency*, thus taking into consideration the human eye's interpretation of discoloration.

Four typical filters were chosen and tests made upon them to determine both the physical and psychological discoloration efficiencies. These tests were made using both porous white filter papers and porous black filter papers for the backgrounds to be discolored and four test dusts as the discoloring media. These dusts were air-floated silica, Pocahontas ash, powdered rosin, and lampblack. In addition, comparisons are reported between all four filters showing the efficiency ratings obtained by eight different methods using Pocahontas ash and six different methods using lampblack.

No specific recommendation is made as a result of this research toward the adoption of any one method of rating the discoloration efficiency of air filters. The results are reported primarily to augment the collective knowledge of the field and to point the direction toward a possible final solution. It is realized that although the method of attacking this problem appears logical, it is, at the same time, somewhat radical, and that further research would be required before general adoption of such a method could result.

NOW IS THE TIME!

As the fall season opens, greater activity in the enlistment of new members is essential in order to reach our goal of four hundred new members this year.

Since January 1st over two hundred and fifty applications have come in, but there are still many men ready to join, men who will be good members, men who will help the Society and who, in turn will be helped by the Society. They simply are waiting an invitation to join.

One new member wrote me that he was astounded at the number of men in his district who should be members but who are not. He promises to do some intensive work on membership.

There are opportunities in many more districts and every member will be asked to participate in building up the Society membership. Full details will be sent soon.

When you ask a man to join the Society you are paying him a compliment and giving him an opportunity to take part in the expansion and the advancement of the profession of heating, ventilating and air conditioning.

If *we* will *all work* on membership now I foresee a Society of 5000 members in the near future.

E. K. CAMPBELL,
Chairman, Membership Committee.

Fuel Conservation Possibilities Shown by Survey of Present Status of Heating Facilities

By K. C. Richmond,* Chicago, Ill.

SUMMARY—This paper covers, statistically, the age, condition, maintenance and operation of the heating facilities in use throughout the United States and the possibilities in fuel conservation.

HOW COMFORTABLE people are during the winter or how satisfactorily or economically their homes or buildings are heated depends on:

1. The way homes, apartments or other structures are built; their age, size, location and exposure; the presence or absence of insulation, weatherstripping, storm windows.
2. The type, design, age, character, condition and maintenance of the heating facilities as a whole.
3. The choice and adaptability of the equipment and the fuel used.
4. The way the heating facilities are operated—the care and skill of the plant operators.
5. Air and wall temperatures. Stratification.
6. The relative humidity, drafts, air movement, mean skin temperatures.
7. The health, physical condition, activity, metabolism, and age of the individual; "the capacity of the heat regulating system as a whole to make prompt adaptive changes in the distribution of blood to the skin and thus preserve heat balance under changing environmental conditions," as C. P. Yaglou has pointed out.
8. The weather, temperature, direction and velocity of the wind, solar radiation.
9. The amount of clothing worn.
10. Relations with the fuel merchant or heating contractor.

The comfort of living in a properly heated home or apartment may be lost, fuel may be wasted, and cost of operation may be increased by any or all of the following factors: deterioration of the heating system, neglect of the heating system, neglect or improper care of the heating appliance, a faulty chimney, lack of proper controls, careless firing, or lack of insulation or storm windows.

Sometimes, for various reasons, a heating system fails to work properly. Actually operated more hours per year than any device in the home except the electric clock, it is subjected to neglect, ordinarily, and gets relatively little attention, not nearly as much as it deserves.

As a result, altogether too many persons are not enjoying the heating comfort that they might, health is jeopardized, 10 to 15 per cent of the fuel purchased is wasted needlessly. (Yet, such waste, in effect, is sabotage, but it is taking place none the less in eight out of ten buildings.)

The Age of Dwelling Units

When the age of the homes or buildings in the average city is checked it becomes fairly evident that much of the heating equipment in use is anything but up-to-date. Study of the latest census figures for some 36 well-known cities covering 4,160,000 dwelling units, shows that 28 per cent of these were built in 1899 or before —38 per cent between 1900 and 1919; 25 per cent between 1920 and 1929—only 7 per cent between 1930 and 1940.

Nationally, one urban dwelling in nine was constructed prior to 1890. One in five is over 40 years of age. In New York State one dwelling in twenty was built over 82 years ago; 18.2 per cent over 50 years ago; 11.3 per cent between 1890 and 1899.

In Pennsylvania, 5.8 per cent of the buildings in the state were constructed prior to 1860; 16.6 per cent between 1860 and 1889—thus over 22 per cent are over 50 years of age. In Pittsburgh, over 40 per cent were built before 1900, which would indicate that many of the heating facilities in use are not all that they might be.

In Ohio, one-third of all dwelling units in the state were built prior to 1899—one in twenty over 80 years ago—one in eight over 70 years ago. In Chicago, 27 per cent of all dwelling units were built prior to 1899; 39.8 per cent between 1900 and 1919. In Cambridge, Mass., more than half were built before 1899; in Milwaukee one in three; in New Haven, two out of five; in Cleveland, one in four; in Baltimore, nearly half—eight out of eleven before 1919.

In New Hampshire, 19.9 per cent were built before 1859; 11.6 per cent between 1860 and 1879; 34.8 per cent between 1880 and 1900. In Vermont, 25 per cent were built before 1860; 15.7 per cent between 1860 and 1879; 62.7 per cent before 1900.

The Condition of Equipment

That the condition of many heating facilities in use leaves much to be desired, is shown by an analysis of the records covering thousands of heating plant inspections by competent engineering personnel.

From over 64,000 furnace inspections by the Koppers Co., it appears that less than 10 per cent of the domestic heating plants are in *satisfactory condition.* Eleven out of twelve have leaks that need sealing.

According to a report of the Chicago Department of Smoke Inspection covering 26,785 annual heating equipment inspections, 9,248 repair notices were sent to building owners.

W. E. Tidmore, director of the Smoke Abatement Bureau in Atlanta, has reported that the department was making recommendations in over 90 per cent of the heating plants inspected—that over 50 per cent are in need of serious repair—that they must be reconditioned before they can be fired efficiently and smokelessly.

The Coal Producer's Committee for Smoke Abatement has recently

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reported on its survey of heating and power plants in several cities. *"A glaring lack of proper maintenance was evident in practically every size of plant,"* the Indianapolis report reads.

Less than 3 per cent of the plants surveyed in Nashville were in first class condition and properly fired—86 per cent of the plants were found to be in need of repairs, additional capacity, or required more careful firing.

Many Defective Heating Plants

Careful records of a leading coal merchant show that out of 2,573 furnaces cleaned, 36 per cent resulted in repair work. No less than 14 per cent of the heating plants cleaned required overhauling, and out of every twenty furnaces cleaned, one home owner bought a new heating plant. Under such conditions, is it surprising that many home owners are not getting all they might from the fuel used?

One dealer's records show that 35 per cent of a large number of furnaces cleaned had leaky joints, 22 per cent required new smoke pipes, and 5 per cent needed new grates.

Records of a number of coal men and others who are cleaning furnaces show that four out of every seven plants need some sort of repair work, usually new smoke pipes, grate bars, or fire pots.

Such conditions are not so surprising when a study is made of the returns of the Census of Housing for 1940. Of our urban dwellings, 2,298,000 were in need of major repairs; among the rural non-farm communities, 1,636,000 were in need of repairs—and among our 7 million farm dwellings, no less than 2,478,000 were reported in need of major repairs.

Conditions in Larger Plants

"Very complete checks on power equipment in operation indicate that nearly half of the present power equipment in industrial power plants is in need of replacement," W. T. Watt, vice-president, *Industrial Power*, once wrote.

Of the gross volume of business of one of the largest manufacturers of industrial boiler room equipment, over half has come from repairs and maintenance sales in recent years.

One of the coal industry's outstanding engineers says, "There are a large number of plants we run into that need overhauling, or repairs of one kind or another. It is really surprising how few complaints we get that are actually due to the coal itself. Almost 100 per cent of the complaints we are called on to service are due to faulty equipment or faulty methods of firing the coal, the latter including coal feed and manipulation of drafts."

Still another engineering authority declares that 45 per cent of the power plants should be overhauled, 20 per cent are in deplorable condition, and ready to junk, 20 per cent he concedes are so-so, and 15 per cent of them are excellent.

"There have been few industrial plants that I have had occasion to inspect that did not present opportunities for improvement," as J. F. Barkley, now Chief, Division of Solid Fuels Utilization for War, Bureau of Mines, has explained.

"Our inspectors find heating plants in such condition that it is almost unbelievable. They have found boilers with soot 1½ in. thick on all the heating surfaces. The amount of fuel used is twice as much as necessary," as W. G. Christy, smoke abatement engineer, Hudson County, N. J., points out.

Obviously, a great many heating difficulties and complaints are more or less inevitable under such circumstances.

What's Behind the Heating Difficulties

Engineers in the employ of the Kansas City Coal Service Institute found, for instance, from a study of 1,003 complaints, that 42 per cent of these were due to faulty equipment, 40 per cent to improper firing.

Carl Klermund, who has probably handled as many heating complaints personally as anyone in Chicago, recently analyzed a few months' records covering 1,359 service calls. Of these, 57 per cent were directly traceable to the character and condition of the heating system, 39 per cent to the operation of the plant, 3 per cent to coal, and 1 per cent to chronic kickers.

Records covering 6,787 service calls by anthracite service engineers disclosed that 73 per cent of the complaints were due to faulty equipment, 26 per cent to wrong firing and care, and 1 per cent to coal.

Stewart Orgain of the Chicago Coal Merchants Association, recently analyzed some 600 service reports. From his records it appears that 61.3 per cent of the calls were due to improper operation, 23.7 per cent to faulty equipment, 8 per cent to coal, 7 per cent to improper sizing and installation of stokers. "Coal was blamed for 95 per cent of the troubles," Orgain says, "yet no less than 92 per cent were due to improper firing methods and faulty equipment."

Fire Losses

One of the serious *by-products* of such carelessness and faulty operation of heating facilities is shown by our annual fire losses. According to the latest figures of the National Fire Protection Association, based on State Fire Marshals' reports for 1941, we lost at least 10,000 lives and 325 million dollars due to 736,000 fires. Note these figures:

Cause	Number of Fires	Loss
Chimney flue, defective or overheated	50,000	$11,400,000
Sparks on roofs	60,000	9,500,000
Defective or overheated boilers	46,000	14,250,000
Combustibles near heaters	9,000	2,100,000
Hot ashes, coals	15,000	2,250,000
Oil burners	12,000	5,000,000
Gas and appliances	3,000	1,250,000
Lamps and stoves	20,000	6,000,000

Thus, over one-fourth of our fires can be charged to heating facilities, as well as a loss of around 50 million dollars annually.

Replacement Needs

When one recalls that approximately three out of five furnaces bought are for replacement use—that as high as 90 per cent of the sales of some leading furnace manufacturers go into old homes—that the *life* of many furnaces is no more than 10 to 12 years—is it not self-evident that the operation and maintenance of many of the heating facilities in use leave considerable to be desired? (Over 11 million furnaces have been sold, yet

the census figures show but 7 million dwellings so heated.) An average of over 200,000 warm air furnaces, and over 100,000 boilers have been replaced annually.

With the pent up demands owing to the war priorities, restrictions on the purchase of new equipment at present, the heating industry faces one of the largest potential markets in this country, when the war ends. Some 24 million heating plants could be modernized or replaced to advantage.

Beyond any question, eight out of ten fuel using plants now need attention—inspection, cleaning, adjustment, alterations, repairs and modernization—but they are not getting such attention because the owners have not been sold. So, *educating* or selling them on the advantages of such efforts is the job today. It will help win the war, too.

Plant Operation

Experience shows, as we have indicated, that a comparatively small percentage of domestic or other smaller users of fuel have any real conception of the many factors that affect their heating comfort, what happens to the heat they buy, or what is involved in the proper operation and maintenance of the heating systems in their homes, buildings or plants. One reason for this is that half of the heating equipment is in the basement, out of sight, and people have been inclined to spend money where it would show—which has cost the heating industries millions of dollars in business it did not get.

No fuel, it must be remembered, is any better than the equipment in which it is used, and the equipment, in turn, is no better than the skill of the operator.

People are not born with an instinctive skill that enables them to operate a heating system properly; it takes some instruction to learn how to operate a heating plant properly just as it does to play golf or to get some music out of a violin.

In the apartment house field the owner is sometimes fortunate in having an excellent janitor who *knows what it is all about*, and who operates the heating system satisfactorily and economically. More often than should be the case, however, the skill, interest and activity of the janitor falls short of what the owner expects, especially when the latter is none too familiar with the problems of heating, or is inclined to skimp on the maintenance, and modernization of the heating system.

Getting or holding on to a skilled, conscientious janitor, is not always easy. How much the building owner can afford to pay to get or keep an exceptionally good fireman, is not a question to be dismissed too lightly. Trying to save a few dollars on labor may result in higher costs of operation. The more skilled or capable the operator of the heating system, the better the heating, and the lower the costs. Since the fuel purchased and heating system are no better than the ability of the individual who uses them, the importance of the *human equation* cannot be overemphasized.

Satisfactory, economical heating does not *just happen*. Someone must take the responsibility—see that the plant is in good condition, that it is properly operated and maintained, that heat is put where it is needed—not wasted, that costs are in line. Buck-passing is futile.

Possibilities in Fuel Conservation

"Various surveys have shown that combustion efficiency in the use of much of our coal output is too low and that effective effort would improve the use of at least 300,000,000 tons of coal per year 10 to 15 per cent," as Mr. Barkley has further pointed out.

Fuel is one of the bulkiest items of transportation, and the consumption of less fuel will relieve the mines as well as transportation facilities, an exceedingly important consideration at present. It is estimated that 25,000 coal miners working one year would be needed to mine the above indicated saving in coal, which would fill about 670,000 railroad cars.

Mr. Barkley also stated that waste of fuel at this time gives definite help to our enemies, and all efforts should be made to prevent it. This country must conserve to the utmost its fuel resources—basic war power.

In a report on domestic heating, it was brought out by H. Langdon and H. J. Dana of the State College at Washington, that, owing to the inefficiency of hand firing methods and the poorly designed heating plants, only 30 to 40 per cent of the heat in coal ordinarily finds its way into the home, the rest is wasted.

The late Dr. H. B. Meller, when chief of the Air Pollution Investigation of Mellon Institute, Pittsburgh, said the preventable waste of fuel in the United States is tremendous, that it amounts to 20 per cent of the fuel used.

Careful investigation by the Anthracite Industries Laboratory in the field shows that overheating in hand-fired plants without automatic temperature controls results in an avoidable average seasonal fuel loss of 11.7 per cent.

With the country at war, the demand on transportation facilities, the loss of 60,000 miners to the draft, the restrictions on the purchase of new heating equipment, there is no reason why 50 million tons of coal and so much oil and gas should be produced and transported this winter only to be wasted through improper use.

This country might just as well save 5 to 10 per cent of the fuel—or some 50 million tons—four weeks' coal production this year. It can be done with no expense for new equipment.

What Has Been Accomplished

Back in 1919-20 the railroads used 170 lb of coal per 1,000 gross ton-miles freight service — today they are using 111—a 34.7 per cent reduction since the first World War. In pounds of coal per passenger-train car-mile, the reduction has been from 18.5 to 14.9, or 19.5 per cent.

In the utility field, 1.3 lb of coal does as much as 3.2 lb did in 1919, a reduction of 59.4 per cent. In the iron and steel industry the amount of coking coal per gross ton of pig has dropped from 3,577 to 2,828, or 20.9, which shows what has been done in the larger field.

Thousands of power plants have shown marked improvements in operating economics in recent years, thanks to improved design, the use of stokers, combustion controls, instrumentation, develop-

ments in coal preparation, and skilled operating personnel.

But in the residential field, except for buildings with stokers, and modern heating facilities, far too much fuel is now being wasted unnecessarily. Yet there is no excuse for wasting one ton of coal out of every five used for domestic heating purposes, particularly when half of such losses could be prevented at little or no expense to the fuel user.

That such savings are readily possible, will be confirmed by any experienced heating engineer or smoke inspector. For instance, merely cleaning the heating plant can cut fuel losses 5 per cent; repainting aluminum or bronze covered radiators with oil paint will increase the heat output 9 per cent —to cite but two out of many means of cutting heat losses.

Ten Ways to Save Fuel

If, in some way, the findings of the War Service Committee of the ASHVE covering "Ten Ways to Save Fuel and Improve Heating Plant Efficiency" can be brought home to the American public, more than 50 million tons of coal can be saved annually. (See pp. 865-868, Heating, Ventilating, Air Conditioning Guide, 1943.) These suggestions are specific, practical, and timely. To take advantage of possibilities will improve the heating results in the average home or building very materially, cut costs, protect health, conserve the use of critical war materials, aid the war effort.

Fuel Saver Compounds

In a period when public attention is directed to the necessity of saving fuel, interest is aroused in all real or alleged means of accomplishing this purpose. *Fuel Savers* so-called which are supposed to obtain from the fuel greater quantities of heat than actually exist in the combined fuel and fuel savers make their appearance in greater number than usual.

The arrival at ASHVE headquarters of an increased number of requests for information and recommendations regarding the use of fuel saving compounds is evidence of the appeal which the advertisers claim makes upon the public.

A review of conclusions drawn by various authorities is given in a research bulletin, Facts About So-called Coal Savers, issued in March 1943 by the National Better Business Bureau, Inc. Results of U. S. Bureau of Mines investigation of *Fuel Savers* are given in Bulletin 360, Removal of Soot from Furnaces and Flues by the Use of Salt or Compounds, by P. Nicholls and C. W. Staples, and in Bulletin 404, Burning Coal and Coke Treated with Small Quantities of Chemicals, by P. Nicholls and others. Metallic chlorides were found, according to the late Percy Nicholls and his associates, to be the most effective soot removal agents, the best being copper chloride which was followed in decreasing effectiveness by lead chloride, zinc chloride, and rock salt. It was also found that mixtures of the metal or some compound of the metal with common salt gave the same effect as the metal chloride.

A recent survey among ASHVE members having experience with so-called *Fuel Savers* or soot removal compounds yielded results which lead to the conclusion that the only possible value any compound sprinkled on the fuel may have is to lower the ignition point of soot which has collected on the heating surfaces. Usually a hot fire is necessary to ignite the soot and the resulting chimney and smoke pipe temperature may itself be a fire hazard. When the compounds cause the soot to burn the remaining ash must still be removed from the flues and smoke pipe, hence the use of the compound reduces the labor but does not eliminate the necessity of cleaning the heating surface by brushing or scraping.

The *secret ingredient* of many so-called soot removers is common salt and results obtained with many compounds may be duplicated by use of a handful of common salt thrown on a hot fire.

Occasionally the purchaser of a compound for improving combustion pays more attention to the operation of the fire because of instructions supplied by the vendor of the compound and achieves an improvement in coal consumption which is credited to the compound whereas it is really due to more intelligent manipulation of the fire.

Chemicals which release oxygen may be effective in removing soot if used sparingly and frequently but they may be somewhat explosive and require care in handling and use.

At any rate compounds must be used with care and discretion lest dangerous fires result from the too rapid burning of the soot.

The War Service Committee

of the

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

urges members to support the government

"ORDER COAL NOW"

and

"FUEL CONSERVATION"

programs to the fullest extent. Let it be known that an important amount of fuel can be saved by increasing the efficiency of the boiler or furnace as a heat conversion plant and by increasing the efficiency of the building as a structure that will retain the heat supplied to it.

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ZINK, D. D., Major, G.S.C., 1st Arm'd Corps.

*Compiled as of August 15, 1943.

U. S. Navy

AKERS, G. W., Lt.-Comdr., U.S.S. Markab.
ANDREWS, W. G., Mach. A-V (S), USNR.
ASH, R. S., Lt. (jg), USNR.

BABER, J. E., Lt., U.S.S. Bainbridge.
BAKER, H. L., Jr., Lt. (jg), USNR.
BAKER, R. H., Comdr., USNR.
BASTEDO, G. R., Ensign, USNR.
BOUILLON, Lincoln, Lt. (CEC), USNR.
BOYD, S. W., Lt., USNR.
BRAUN, C. R., Jr., Midshipman, USNR.
BRISSENDEN, C. W., Lt. (jg.), USNR.
BURGES, J. H., Apprentice Seaman, USNTS.

CARTER, J. H., Lt., USNR.
CARY, E. B., Comdr. (CEC), USNR.
CHAPMAN, W. A., Jr., Lt., USNR.
CHILDS, L. A., Lt., E-V (S), USNR.
CHIPMAN, E. E., Jr., Ensign, USNR.
COOPERMAN, E., S/2c, ABHTU, NAS.
COVER, R. R., Warrant Officer, E-V (S), USNR.
CURLEY, E. I., Lt., USNR.

DADDARIO, F. T., Ensign, USNR.
DANOWITZ, C. J., Ensign, USNR.
DAVIDSON, J. C., Lt. (jg), USNR.
DOVENER, R. F., Lt. (jg), USNR.

EGGERS, W. K., Ensign, USNR.
EUTSLER, E. E., Jr., Lt., USNR.
EVANS, R. W., Lt.-Comdr. (CEC)-V (S), USNR.
EVERETTS, John, Jr., Lt. O-V (P), USNR.

FLORETH, J. J., Lt. (jg), USNR.
FORBES, H. B., Jr., Ensign, USNR.

GREGG, S. L., Lt., USNR.
GRIEST, K. C., Warrant, (CEC), USNR.

HART, J. H., Lt. (jg), USNR.
HERO, G. A., Jr., Lt.-Comdr., USNR.
HERRE, H. A., Ensign, E-V (S), USNR.
HERTZLER, J. R., Lt., USNR.
HOLLAND, W. T., Lt. (jg), USNR.
HOUGHTEN, F. C., Lt.-Comdr., USNR.

JOHNSON, L. O., USNR.
JOHNSTON, R. M., Lt. (jg), USNR.
JORDY, J. J., Lt., USNR.

KAHN, C. R., Jr., Lt. (jg), USNR.
KEYES, M. W., Lt. (jg), USNR.
KILLIAN, W. J., Lt. (jg), USNR.
KOLB, R. P., Lt.-Comdr., USNR.

LADD, David, Lt.-Comdr., USNR.
LANDAUER, L. L., Lt.-Comdr. (CEC), USNR.
LANGE, F. F., Lt., USNR.
LEVINE, L. J., Ensign, USNR.
LEVITT, L. L., Lt. (jg), USNR.
LIEBLICH, Murray, Ensign, USNR.
LOCKE, R. A., Lt.-Comdr., USNR.

MABLEY, L. C., Lt.-Comdr., USNR.
MATHEKA, C. R., U.S.S. Tattnall.
MATTHIES, L. A., Ensign, USNR.
MAY, M. F., Lt., USNR.
MCDOWELL, H. L., Ensign, USNR.
MELTON, R. D., C.M. 1/C, NCTC.
MILLARD, J. W., Lt., Organized Reserve.
MITCHELL, A. J., Lt. (jg), USNR.
MORSE, L. S., Jr., Lt. (jg), USNR.

NOYES, R. R., Ensign (AUS), USNR.

PAETZ, G. A., Ensign, USNR.
PARKINSON, J. S., Lt.-Comdr., USNR.
PELLER, Leonard, Lt. (jg), USNR.
POWERS, E. D., Lt. (jg), USNR.

QUEER, E. R., Lt. (jg), USNR.

RAY, G. E., Apprentice Seaman, USCG.
REED, W. H., Lt. (jg), USNR.
RILEY, J. N., Lt. (jg) E-V (S), USNR.
RODEE, E. J., Lt., USNR.
ROGERS, C. S., Lt. (jg), USNR.

SCHECHTER, J. E., Lt. (jg) USNTS.
SHAPIRO, C. A., Ensign, D-V (S), USNR.
SIMPSON, R. L., Lt. (jg), USNR.
STACEY, A. E., Jr., Capt., USNR.
STEEL, R. J., Lt., USNR.
STERNE, C. M., Lt.-Comdr., USNR.
SULLIVAN, T. J., Ensign, USNR.

TIMMIS, W. W., Lt.-Comdr., USNR.
TRACY, W. E., Lt. (jg), USNR.
TURNER, J. P., Jr., Lt. (jg), USNR.

URDAHL, T. H., Comdr., E-V (S), USNR.

VAN ALSBURG, J. H., Lt., USNR.
WESTPHAL, N. E., Ensign, USNR.
WIDDOWFIELD, A. S., Lt. (jg), USNR.
WILLIAMS, F. H., Lt. (jg), USNR.
WILSON, A. M., Ensign, USNR.
WORKMAN, A. E., Lt. (jg), USNR.

YOUNGER, J. R., USNTS.

ZUROW, W. A., Ensign, USNR.

Members in Allied Forces

ARMOUR, E. G., RCAF.

BALLANTYNE, G. L., Instructor, RCAF.
BARRETT, C. M., Canadian Active Service Forces.
BISHOP, J. W., Lt.-Col., Canadian Active Service Forces.
BODMER, Emmanuel, Lt., Air Force.
BOWERMAN, E. L., Flying Officer, RCAF.
BUTT, Roderick E. W.

DANIEL, W. E., 2nd Lt., Royal Artillery.
DOWLER, E. A., 1st Lt., Canadian Army, RCE.

FOX, J. H., Major, Ordnance Co., Canadian Army.

JOHNS, C. F., Sqdn. Leader, RCAF.

KITCHEN, W. H. J., Elec. Lt., Royal Canadian Naval Volunteer Reserves.

LABONNE, Henri, Lt., "Les Fusiliers de Sherbrooke."

MACLACHLAN, V. D., Flight Lt., Royal Air Force Volunteer Reserves.

NORFOLK, L. W., Lt.-Col., H.M. Forces, Royal Engrs.
NOVOLANSKY, S. I., Flight Sgt., RCAF

PENNOCK, W. B., Lt.-Col., RCE, 8th Canadian Div.
POUGHER, B. R. E., Sgt., 110 (el) A.T. Coy R.E.
PRICE, Ernest H., Lt., RCE.
PRYKE, J. K. M.,† Capt., Royal Army Ordnance Corps.

RICHARDSON, R. D., Sgt., Royal Regt. Artillery.
ROBINSON, Jack A.

SMITH, G. E., RCE.

TEMPLE, H. L., F/O, RAF.

WILKINSON, Arthur, Flight Lt., RCAF.
WOOD, A. W., RCAF.

†Prisoner of War.

BUY MORE WAR BONDS NOW!

NEW CHAPTER FORMED

Indiana members of the Society met September 2 at the Lincoln Hotel, Indianapolis, to discuss plans for the organization of a local chapter. National officers of the Society were present at the meeting, and Pres. M. F. Blankin, Philadelphia, spoke on An Engineering Society's Activities in War Time. He outlined the value of Society membership, the public service that can be rendered by a local organization in a community, and some important facts about the Society's research work, which is helpful to government agencies and to war production work. He said that the Society is about to enter its 50th year of service, and the 50th Annual Meeting of the Society is scheduled for New York, January 31, February 1 and 2, 1944. He congratulated the Indiana group on the fact that two men from Indiana, J. G. Hayes, Indianapolis, and W. R. Stockwell, Michigan City, held life memberships in the Society.

At the meeting other visiting officers who participated in the program were: W. A. Russell, Kansas City, Mo., member of the Council; A. V. Hutchinson, New York, secretary of the Society; and the presidents of three local chapters, Albert Buenger, Cincinnati, C. E. Price, Chicago, and Carl Boester, St. Louis, Mo. Local arrangements for the meeting were made by C. H. Hagedon, with the assistance of W. C. Bevington, S. E. Fenstermaker, J. G. Hayes, J. H. Niesse, R. E. Poehner, E. N. Sanbern, C. W. Stewart, G. B. Supple, and G. A. Voorhees.

LIFE MEMBER H. V. BAYSE DIES AT 73

Word has been received of the recent death of Harry V. Bayse, Chairman of the Board, American Furnace Co., St. Louis, Mo. He was born on August 18, 1870 in New Haven, Ill., where he received his early education. In 1889 he became employed by the Front Rank Furnace Co., later known as the Haynes-Langenberg Mfg. Co., and in 1900 he opened his own business specializing in designing warm air heating and ventilating plants. He maintained his own business for over twenty years, when he became President of the American Furnace Co.

Mr. Bayse joined the ASHVE in 1923, and was voted a Life Member of the Society by the Council in 1941.

His presence will be greatly missed by his many friends and colleagues in the St. Louis Chapter, as well as by his associates in the Society.

The Officers and Council of the Society extend their sincere sympathy to his family who survive.

C. A. EVANS DIES IN BUFFALO

Charles A. Evans, founder and owner of the C. A. Evans Co., Buffalo, N. Y., passed away on May 30 after an illness of five months. He was born September 4, 1874, in Philadelphia, Pa., where he received his elementary training. He devoted his entire life work to the plumbing and heating field, and was superintendent of plumbing installations in many of Buffalo's largest buildings.

Mr. Evans joined the Society in 1919 and maintained membership for over 17 years. He was active in the West New York Chapter, and served as its First Vice-President and President in 1927 and 1928, and as a member of the Board of Governors in 1929-30. He was a former director of the Master Plumbers' Association of Buffalo.

He will be missed by his friends and associates in and around Buffalo, as well as by his many friends and acquaintances in the Society. News of his passing has just been received by the officers and Council, who extend their sincerest sympathy to his widow and son, who survive.

Candidates for Membership

The Constitution of the Society, as now amended, requires the following mode of procedure in voting on applicants for membership in the Society. All applications for membership are to be sent to the Secretary and the names of applicants and their references shall be printed in the next issue of the Journal of the Society or sent to the members in other approved manner as ordered by the Council. When replies are received from references, the Candidate's application shall be submitted to and acted upon by the Committee on Admission and Advancement as soon as possible.

When the Committee on Admission and Advancement has acted favorably upon a Candidate's application and assigned his grade, the Council shall vote upon the election of the proposed Candidate for membership by letter ballot. During the past month 24 applications for membership have been received and the names of these men and their sponsors are published in the following list.

Members are requested to scrutinize the list with care. The Committee on Admission and Advancement, and in turn, the Council, urge members to assume their share of responsibility of receiving these candidates into membership by advising the Secretary promptly of any whose eligibility for membership is in any way questioned.

All correspondence in regard to such matters is strictly confidential, and is solely for the good of the Society, which it is the duty of every member to promote.

Unless objection is made by some member by September 15, 1943, these candidates will be balloted upon by the Council. Those elected to membership will be notified by the Secretary immediately after election.

CANDIDATES	REFERENCES	
	Proposers	*Seconders*
ANDERSON, SYDNEY, JR., Mgr., Refrigeration & Air Cond. Dept., Fairbanks, Morse & Co., Atlanta, Ga.	L. F. Lawrence, Jr. A. H. Koch	J. J. O'Shea S. W. Boyd
BERGMAN, A. E., Pres., A. E. Bergman, Inc., St. Paul, Minn.	K. C. Richmand A. B. Newton	*H. F. Diver J. E. Haines
BRAKHA, M. V., Gen. Mgr., Carrier Egypt, S.A.E., Cairo, Egypt.	W. H. Carrier V. S. Day	R. V. D. Dunne N. E. Sheldon
CHEASLEY, THOS. C., Fuel Engr., Sinclair Coal Co. & Affiliates, Kansas City, Mo.	E. K. Campbell D. M. Allen	L. T. Mart J. M. Arthur
CROSS, WILLIAM D., Mech. Engr., Sherman Sleeper Associates, Camden, N. J.	L. B. Ray A. H. Bermel	C. F. Wiltberger D. T. Buck

FRANKFURT, W. W., Chief Mech. Engr., Austin Co., Oklahoma City, Okla.

FRITSCHE, CARL, Heating Engr., American Radiator & Standard Sanitary Corp., Newark, N. J.

GRANT, WALTER A., Dir., Application Engrg., Carrier Corp., Syracuse, N. Y. *(Advancement)*

GREENWOOD, L. D., Engr. Air Conditioning Co., Houston, Tex.

HILL, H. G., SR., Draftsman, Toronto Shipbuilding Co., Ltd., Toronto, Ont., Canada. *(Advancement)*

HUHN, WALTER E., Contractor and Engr., Walter E. Huhn, Waukegan, Ill.

KAUFMAN, AARON M., Student, Purdue University, W. Lafayette, Ind.

KNOX, WALTER, Development Engr., H. D. Conkey Co., Mendota, Ill.

KOEHLER, GEO. N., Dist. Repr., Minneapolis Honeywell Regulator Co., New Orleans, La.

LAUBE, H. L., Vice-Pres., Carrier Corp., Syracuse, N. Y.

MINSON, FREDERICK L., Marine Engr., U. S. Maritime Commission, New Orleans, La.

MOULSDALE, THOMAS DEWITT, Heating Engr., Lehigh Valley Oil Co., Allentown, Pa.

MUTH, ARNOLD J., Elec. Engr., Albert Kahn Associated Architects & Eng., Inc., Detroit, Mich.

NUNLIST, F. J., JR., Ass't Chief Engr., L. J. Mueller Furnace Co., Milwaukee, Wis.

PRIDE, HAROLD K., Dist. Mgr., Minneapolis Honeywell Regulator Co., Milwaukee, Wis.

SHILSTON, R. AYNSLEY, Heating Engrg. Asst., Manchester Corp., Manchester 2, England.

THROLLER, T. H., Dir. of Research, Guggenheim Airship Institute, Akron, Ohio.

TUTTLE, ARTHUR A., Post Engrs. Office, U. S. Army, APO 863, % Postmaster, New York, N. Y.

WEBER, FRANK J., Manufacturers' Representative, Frank J. Weber & Associates, Buffalo, N. Y.

T. H. Anspacher
L. C. McClanahan
J. H. Reilly
C. W. A. Steinmetz
E. T. Murphy
L. L. Lewis
J. A. Walsh
H. U. Bible
H. H. Angus
W. C. Kelly
J. S. Kearney
E. M. Mittendorff
William Miller
W. R. Rhoton
K. C. Richmond
C. E. Shaffer
Fritz Gutknecht
L. V. Cressy
W. H. Carrier
C. M. Ashley
A. R. Salzer
H. H. Roberts
A. C. Glance
J. W. Singmaster
E. M. May
P. A. L. Foulds
C. H. Flink
H. P. Mueller
F. W. Goldsmith
J. H. Volk
G. R. Jackson
G. N. Haden
T. H. Urdahl
J. H. Van Alsburg
A. L. Walters
F. L. Meyer
E. N. McDonnell
M. F. Blankin

L. S. Gilbert
E. T. Gessell
R. R. Ferguson
*J. H. Fitzsimmons
W. L. Yerkes
C. M. Ashley
W. M. Andrews
D. S. Cooper
H. S. Moore
A. J. Strain
R. O. Nelson
C. M. Burnam, Jr.
*W. G. Clark
*R. C. Binden
*G. V. McGurl
*C. C. Russell
J. J. Joyce
G. C. Kerr
W. H. Driscoll
*D. D. Wile
L. V. Cressy
John Devlin
C. B. Korn
A. H. Schroth
C. T. Flint
*G. C. Whittaker
N. M. Blanchard
M. L. Lavorgna
A. S. Krenz
C. H. Randolph
Robert Cupitt
*Frederick Buckingham
W. C. Whittlesey
A. E. De Somma
*R. O. Papenthein
F. W. Hauer
C. W. Stewart
H. C. Murphy

*Non-member.

Candidates Elected

In the past issues of the Journal of the Society the names of the following men were listed as Candidates for Membership. The membership grade of each candidate has been assigned by the Committee on Admission and Advancement and balloted upon by the Council. We are now instructed by the Council to post herewith, as required by Art. B-111, Sec. 8, of the By-Laws, the following list of candidates elected:

MEMBERS

ANWAY, H. WILBUR, Research Physicist, Wood Conversion Co., Cloquet, Minn.

BORNSTEIN, WILLIAM, Heating Contractor, William Bornstein & Son, Washington, D. C. *(Advancement)*

BRANDT, F. C., Engr., Minneapolis-Honeywell Regulator Co., Houston, Tex.

COLLINS, J. A., Mgr., Frontier Engineering Corp., Buffalo, N. Y.

CUMMINGS, IRA R., Engr., Westinghouse Electric & Mfg. Co., Cleveland, Ohio.

HOGER, B. E., Staff Engr.-Mech. Engr., Basic Magnesium, Inc., Las Vegas, Nev.

JOHANNESEN, RALPH C., Mechanical Engineer, Giffels & Vallet, Inc., Detroit, Mich.

JONES, HUBERT L., Mech. Engr., W. W. Ahlschlager & Assoc., Dallas, Tex. *(Reinstatement & Advancement)*

KEGARISE, R. R., Mech. Engr., Koppers Co., Pittsburgh, Pa.

KELL, WALDO R., Vice-Pres., The Marley Co., Inc., Kansas City, Kans. *(Reinstatement & Advancement)*

KERR, ROBERT, General Mgr., Universal Sheet Metals, Ltd., Toronto, Ont.

KETCHUM, E. R., Engr., The Marley Co., Inc., Kansas City, Kans.

LEE, J. A., Mgr., Contract Dept., Kelvinator Division, Nash-Kelvinator Corp., Detroit, Mich. *(Advancement)*

MCDERMOTT, PAUL F., Section Chief, Research Laboratory, Johns-Manville, Manville, N. J.

MILWARD, R. K., Branch Mgr., U. S. Radiator Corp., Detroit, Mich. *(Advancement)*

SCHOERNER, RUDOLPH T., Chief Engr. and Production Mgr., Taco Heaters, Inc., Providence, R. I.

YOUNG, C. C., Utilization Engr., Lone Star Gas Co., Dallas Division, Dallas, Tex.

ASSOCIATES

ANDERSON, GRANVILLE W., Service Engr., Koppers Coal Division, Detroit, Mich.

ETIE, W. R., Owner, W. R. Etie, Sheet Metal & Heating, Houston, Tex.

FISHER, BERT P., Owner & Mgr., Southern Furnace & Supply Co., Houston, Tex.

LEWIS, VELMA I., Sec'y-Treas. & General Mgr., Dwight Oil Heat, Albany, N. Y.

NIEMOELLER, ARTHUR R., Sales Repr., The Louis Allis Co., Milwaukee, Wis.

PATTERSON, RALPH A., Sales Mgr., Bell & Gossett Co., Morton Grove, Ill.

POUJADE, JAMES V., Chief, Refrigeration Unit, R & U Branch, Hq. Fourth Service Command, Atlanta, Ga.

ROBINSON, CLAUDE A., Owner, Robinson Radiant Heat, Detroit, Mich.

SCHAMPEL, HOWARD B., Plumbing & Heating Supt., Al Johnson Construction Co., New York, N. Y.

STONE, A. A., Mgr., Dallas Branch, Mundet Cork Corp., Brooklyn, N. Y.

VIA, CLARENCE W., Mech. Engr., Black & Veatch, Kansas City, Mo.

ZANONE, H. A., Supt. of Plumbing & Heating, Commonwealth of Kentucky, Frankfort, Ky.

JUNIORS

BELLMAN, JOHN V., Engr., Salem Engineering (Canada) Ltd., Toronto, Ont., Canada.

KAZLOUSKAS, ANTHONY, Junior Engr., Mech., Wilbur Watson & Associates, Cleveland, Ohio.

LUNT, WILBUR F., Fuel Oil Consultant, O.P.A., Boston, Mass.

Officers

President.....M. F. BLANKIN
First Vice-President.....S. H. DOWNS
Second Vice-President.....C.-E. A. WINSLOW
Treasurer.....E. K. CAMPBELL
Secretary.....A. V. HUTCHINSON
Technical Secretary.....CARL H. FLINK

Council

M. F. BLANKIN, *Chairman* S. H. DOWNS, *Vice-Chairman*

Three Years: J. F. COLLINS, JR., JAMES HOLT, E. N. MCDONNELL, T. H. URDAHL.

Two Years: L. G. MILLER, A. J. OFFNER, A. E. STACEY, JR., B. M. WOODS.

One Year: E. O. EASTWOOD, A. P. KRATZ, W. A. RUSSELL, L. P. SAUNDERS, C. TASKER.

Council Committees

Executive—E. O. Eastwood, *Chairman;* A. P. Kratz, E. N. McDonnell.

Finance—J. F. Collins, Jr., *Chairman;* C.-E. A. Winslow, B. M. Woods.

Membership—E. K. Campbell, *Chairman;* A. J. Offner, W. A. Russell.

Meetings—S. H. Downs, *Chairman;* James Holt, C. Tasker.

Standards—L. P. Saunders, *Chairman;* L. G. Miller, T. H. Urdahl.

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Advisory Council

E. O Eastwood, *Chairman;* Homer Addams, D. S. Boyden, W. H. Carrier, S. E. Dibble, W. H. Driscoll, W. L. Fleisher, H. P. Gant, F. E. Giesecke, E. Holt Gurney, L. A. Harding, H. M. Hart, C. V. Haynes, E. Vernon Hill, John Howatt, W. T. Jones, D. D. Kimball, G. L. Larson, S. R. Lewis, Thornton Lewis, J. F. McIntire, F. B. Rowley and A. C. Willard.

Special Committees

Admission and Advancement: E. P. Heckel, *Chairman (one year);* T. T. Tucker *(two years);* H. Berkley Hedges *(three years).*

ASHVE-ASTM-ASRE-NRC Committee on Thermal Conductivity—F. C. Houghten, *Chairman;* C. B. Bradley, H. C. Dickinson, R. H. Heilman, E. R. Queer, F. B. Rowley, T. S. Taylor, G. B. Wilkes.

ASHVE-IES Joint Committee on Lighting and Air Conditioning—H. M. Sharp, *Chairman;* W. R. Beach, B. C. Candee, W. G. Darley, C. L. Kribs, Jr., P. M. Rutherford, Jr.

Chapter Relations—J. F. Collins, Jr., *Chairman;* L. P. Saunders, H. E. Sproull.

Constitution and By-Laws—L. T. Avery, *Chairman;* M. W. Bishop, R. A. Miller.

F. Paul Anderson Award—S. H. Downs, *Chairman;* Tom Brown, F. E. Giesecke, L. L. Lewis and F. B. Rowley.

Guide Publication—P. D. Close, *Chairman;* Thomas Chester, John James, S. Konzo, C. S. Leopold.

Publication—C. H. B. Hotchkiss, *Chairman (one year);* J. H. Walker *(two years);* L. E. Seeley *(three years).*

War Service—John Howatt, *Chairman;* W. H. Driscoll, E. N. McDonnell, L. E. Seeley, B. M. Woods.

Nominating Committee

Chapter	*Representative*	*Alternate*
Atlanta	T. T. Tucker	L. F. Kent
Cincinnati	M. E. Mathewson	E. W. McNamee
Connecticut	L. E. Seeley	H. E. Adams
Delta	G. E. May	G. C. Kerr
Golden Gate	B. M. Woods	
Illinois	E. M. Mittendorff	A. O. May
Iowa	F. E. Triggs	C. W. Helstrom
Kansas City	L. T. Mart	M. M. Rivard
Manitoba	Ivan McDonald	Einar Anderson
Massachusetts	E. G. Carrier	A. C. Bartlett
Michigan	M. B. Shea	S. S. Sanford
Minnesota	R. E. Backstrom	William McNamara
Montreal	G. P. Ste-Marie	R. R. Noyes
New York	H. H. Bond	C. S. Koehler
Nebraska	B. G. Peterson	W. R. White
North Carolina	F. E. P. Klages	Arvin Page
North Texas	T. H. Anspacher	
Oklahoma	E. T. P. Ellingson	E. F. Dawson
Ontario	V. J. Jenkinson	H. R. Roth
Oregon	B. W. Farnes	
Pacific Northwest	R. D. Morse	E. H. Langdon
Philadelphia	H. H. Mather	Edwin Elliot
Pittsburgh	E. C. Smyers	E. H. Riesmeyer, Jr.
St. Louis	C. F. Boester	M. F. Carlock
South Texas	J. A. Walsh	A. J. Rummel
Southern California	W. O. Stewart	Leo Hungerford
Washington, D. C.	J. W. Markert	F. A. Leser
Western Michigan	T. D. Stafford	L. G. Miller
Western New York	H. C. Schafer	S. M. Quackenbush
Wisconsin	C. H. Randolph	Ernest Szekely

Officers of Local Chapters

Atlanta: Organized, 1937. Headquarters, Atlanta, Ga. Meets, First Monday. President, A. H. Koch, 3687 Peachtree Rd. Secretary, L. F. Lawrence, Jr., 304-101 Marietta St., Atlanta 3. **Cincinnati:** Organized, 1932. Headquarters, Cincinnati, O. Meets, Second Tuesday. Honorary President, Capt. C. E. Hust, President, Albert Buenger, Hotel Gibson. Secretary, E. J. Richard, 2137 Reading Rd., Cincinnati 2. **Connecticut:** Organized, 1940. Headquarters, New Haven, Conn. President, C. J. Lyons, Wilson Ave., S. Norwalk. Secretary, J. R. Smak, 160 Morehouse Highway, Fairfield. **Delta:** Organized, 1939. Headquarters, New Orleans, La. Meets, Second Tuesday. President, L. V. Cressy, 423 Baronne St., New Orleans 13. Secretary, J. S. Burke, 317 Baronne St., New Orleans 9. **Golden Gate:** Organized, 1937. Headquarters, San Francisco, Calif. Meets, First Wednesday. President, R. A. Folsom, 150 Hooper St. Secretary, R. B. Holland, 1275 Folsom St. **Illinois:** Organized, 1906. Headquarters, Chicago, Ill. Meets, Second Monday. President, Chas. E. Price, Room 1605, 6 N. Michigan Ave., Chicago 2. Secretary, C. M. Burnam, Jr., Room 1605, 6 N. Michigan Ave., Chicago 2.

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Iowa: Organized, 1940. Headquarters, Des Moines, Ia. Meets, Second Tuesday. President, C. W. Helstrom, 1614 Thompson. Secretary, B. E. Landes, 1603 47th St., Des Moines 10. **Kansas City:** Organized, 1917. Headquarters, Kansas City, Mo. Meets, Second Monday. President, M. M. Rivard, 4550 Main St. Secretary, D. M. Allen, 310 Board of Trade Bldg., Kansas City 6. **Manitoba:** Organized, 1935. Headquarters, Winnipeg, Man. Meets, Third Thursday. President, F. L. Chester, 179 Bannatyne Ave. Secretary, F. T. Ball, 810 9th Ave., W., Calgary, Alta. Acting Secretary, Einar Anderson, 152 Bannerman Ave., Winnipeg. **Massachusetts:** Organized, 1912. Headquarters, Boston, Mass. Meets, Third Tuesday. President, E. G. Carrier, 704 Statler Bldg. Secretary, R. T. Kern, 51 Claflin St., Leominster. **Michigan:** Organized, 1916. Headquarters, Detroit, Mich. Meets, First Monday after 10th of month. President, S. S. Sanford, 2000 Second Ave. Secretary, A. E. Knibb, 1003 Maryland Ave., Detroit 30. **Minnesota:** Organized, 1918. Headquarters, Minneapolis, Minn. Meets, First Monday. President, William McNamara, 850 Cromwell Ave., St. Paul. Secretary, A. W. Schultz, 240 Seventh Ave., S., Minneapolis.

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Montreal: Organized 1936. Headquarters, Montreal, Que. Meets Third Monday. President, F. A. Hamlet, 1010 St. Catherine St., W. Secretary, R. R. Noyes, 630 Dorchester St., W. **Nebraska:** Organized, 1940. Headquarters, Omaha. Meets, Second Tuesday. President, G. E. Merwin, 5012 Parker St., Secretary E. F. Adams, 1227 So. 52nd St. **New York:** Organized, 1911. Headquarters, New York, N. Y. Meets, Third Monday. President, R. A. Wasson, 500 Fifth Ave. Secretary, P. G. Griess, 189 Walnut Ave., Bogota, N. J. **North Carolina:** Organized, 1939. Headquarters, Durham, N. C. Meets, Quarterly. President, F. J. Reed, 263 College Station. Secretary, C. Z. Adams, 312 Piedmont Bldg., Greensboro. **North Texas:** Organized, 1938. Headquarters, Dallas, Tex. Meets, Second Monday. President, M. L. Brown, 3500 Commerce St. Secretary, E. T. Gessell, Thomas Bldg. **Northern Ohio:** Organized, 1916. Headquarters, Cleveland, O. Meets, Second Monday. President, P. D. Gayman, 2142 E. 19th St. Secretary, G. B. Priester, Case School of Applied Science, Cleveland 6.

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St. Louis: Organized, 1918. Headquarters, St. Louis, Mo. Meets, First Tuesday. President, C. F. Boester, 101 E. Essex, Kirkwood. Secretary, B. C. Simons, Rm. 706, 4030 Chouteau, St. Louis 10. **South Texas:** Organized, 1938. Headquarters, Houston, Texas. Meets, Third Friday. President, A. M. Chase, Jr., Box 359. Secretary, A. F. Barnes, 602 Kirby Bldg., Houston 2. **Southern California:** Organized, 1930. Headquarters, Los Angeles, Calif. Meets, Second Wednesday. President, W. O. Stewart, 153 W. Avenue 34. Secretary, Maron Kennedy, 5051 Santa Fe Ave. **Washington, D. C.:** Organized, 1935. Headquarters, Washington, D. C. Meets, Second Wednesday. President, S. L. Gregg, 4828 Edgemoor Lane, Bethesda, Md. Secretary, A. S. Gates, Jr., 111 County Rd., Kensington, Md. **Western Michigan:** Organized, 1931. Headquarters, Grand Rapids, Mich. Meets, Second Monday. President, C. H. Pesterfield, Michigan State College, East Lansing. Secretary, V. H. Hill, 2111 Colvin Court, Lansing 10. **Western New York:** Organized, 1919. Headquarters, Buffalo, N. Y. Meets, Second Monday. President, S. M. Quackenbush, 117 W. Tupper St. Secretary, Herman Seelbach, Jr., 45 Allen St. **Wisconsin:** Organized, 1922. Headquarters, Milwaukee, Wis. Meets, Third Monday. President, F. W. Goldsmith, 513 E. Day Ave. Secretary, E. W. Gifford, 611 N. Broadway

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